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FAST TURKISH PROTECTED CRUISER "ABDUL HAMID."

In respect of the age and efficiency of its ships, the Turkish navy cannot be said to have a very homogeneous appearance. The armored ships, without exception, are the most ancient collection of fighting vessels to be found in any navy to-day, many of them having been launched as far back as 1864, and none of them later than 1885. The cruisers are more modern, the first of them having been launched in 1890, the latest vessels bearing the date 1894, while the latest type of two very smart and handsome cruisers launched within the past few months, have all the qualities of the latest vessels of the protected type.

The best of the cruisers are these last-named vessels, one built at Cramps, Philadelphia, and the other at Swick. They have a designed speed of 24 knots an

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hour. The "Abdul Hamid," herewith illustrated, is 330 feet in length, 42 feet in beam, 16 feet in draft, and of a displacement of 3,250 tons. She is a protected cruiser and, therefore, has no side armor, dependence being placed upon a protective deck that is 1½ inches on the flat and 3½ inches on the slopes. A 4½-inch glacis also protects the boiler and engine casings. The guns carry shields, and there is the usual armor upon the conning tower, the latter, as will be seen from our illustration, being of unusually large capacity, and provided with slits or sighting holes which are more numerous and wider and longer than those commonly found on warships. In fact, the officer within the tower would have a pretty clear sweep of the horizon in every direction except astern.

The armament consists of two 6-inch rapid-fire guns, mounted behind shields, one forward and one aft; eight 4.7-inch rapid-fire guns, mounted in broadside, behind shields, the forward and after pair being car-

ried on sponsons to enable them to fire dead ahead and dead astern, respectively. There are also six 1.8-inch rapid-fire guns, mounted one at each end of the main bridge, one at each end of the after bridge, and one on each broadside on the upper deck. Six machine guns are carried in advantageous positions in the tops and on the superstructure.

The vessel is propelled by twin engines of 12,500 indicated horse-power, at a speed of 22.25 knots an hour. The boiler installation is entirely of the Niclausse water-tube type. She carries 731 tons of coal and 360 officers and men. The "Abdul Hamid" is a type of vessel of which Armstrong has built a large number for the smaller navies of the world, especially those of South America. Practically none of this type of cruiser is being built for the large naval powers, its place being taken by what is known as the scout, a vessel which is somewhat smaller, faster, and less heavily armed.



FAST TURKISH PROTECTED CRUISER "ABDUL HAMID."

INVENTION.*

By HON. CHARLES A. PARSONS, M.A., F.R.S., M.I.C.E.

On this occasion I propose to devote my remarks to the subject of invention.

It is a subject of considerable importance, not only to engineers but also to men of science and the public generally.

I also propose to treat invention in its wider sense, and to include under the word discoveries in physics, mechanics, chemistry, and geology.

Invention throughout the middle ages was held in little esteem. In most dictionaries it receives scant reference except as applied to poetry, painting, and sculpture.

Shakespeare and Dryden describe invention as a kind of muse or inspiration in relation to the arts, and when taken in its general sense to be associated with deceit, as, "Return with an invention, and clap upon you two or three plausible lies."

As to the opposition and hostility to scientific research, discovery, and mechanical invention in the past, and until comparatively recent times, there can be no question, in some cases the opposition actually amounting to persecution and cruelty.

The change in public opinion has been gradual. The great inventions of the last century in science and the arts have resulted in a large increase of knowledge and the powers of man to harness the forces of nature. These great inventions have proved without question that the inventors in the past have, in the widest sense, been among the greatest benefactors of the human race. Yet the lot of the inventor until recent years has been exceptionally trying, and even in our time I scarcely think that anyone would venture to describe it as altogether a happy one. The hostility and opposition which the inventor suffered in the middle ages have certainly been removed, but he still labors under serious disability in many respects under law as compared with other sections of the community.

The change of public feeling in favor of discovery and invention has progressed with rapidity during the last century. Not only have private individuals devoted more time and money to the work, but societies, institutions, colleges, municipalities, and governments, have founded many research laboratories, and in some instances have provided large endowments. These measures have increased the number of persons trained to scientific methods, and also provided greatly improved facilities for research; but perhaps one of the most important results to engineers has been the direct and indirect influence of the more general application of scientific methods to engineering.

Sir Frederick Bramwell, in his presidential address to this Association in 1888, emphasized the interdependence of the man of science and the civil engineer, and described how the work of the latter has been largely based on the discoveries of the former, while the work of the engineer often provides data and adds a stimulus to the researches of the man of science. And I think his remarks might be further appropriately extended by adding that since the man of science, the engineer, the chemist, the metallurgist, the geologist, all seek to unravel and to compass the secrets of nature, they are all to a great extent interdependent on each other.

But though research laboratories are the chief centers of scientific invention, and colleges, institutions, and schools train the mind to scientific methods of attack, yet in mechanical, civil, and electrical engineering the chief work of practical investigation has been carried on by individual engineers, or by firms, syndicates, and companies. These not only have adapted discoveries made by men of science to commercial uses, but also in many instances have themselves made such discoveries or inventions.

To return to the subject, let us for a moment consider in what invention really consists, and let us dismiss from our minds the very common conception which is given in dictionaries and encyclopedias that invention is a happy thought occurring to an inventive mind. Such a conception would give us an entirely erroneous idea of the formation of the great steps in advance in science and engineering that have been made during the last century; and, further, it would lead us to forget the fact that almost all important inventions have been the result of long training and laborious research and long-continued labor. Generally, what is usually called an invention is the work of many individuals, each one adding something to the work of his predecessors, each one suggesting something to overcome some difficulty, trying many things, testing them when possible, rejecting the failures, retaining the best, and by a process of gradual selection arriving at the most perfect method of accomplishing the end in view.

This is the usual process by which inventions are made.

Then after the invention, which we will suppose is the successful attempt to unravel some secret of nature, or some mechanical or other problem, there follows in many cases the perfecting of the invention for general use, the realization of the advance or its introduction commercially; this after-work often involves as great difficulties and requires for its accomplishment as great a measure of skill as the invention itself, of which it may be considered in many cases as forming a part.

If the invention, as is often the case, competes with or is intended to supersede some older method, then there is a struggle for existence between the two.

This state of things has been well described by Mr. Fletcher Moulton. The new invention, like a young sapling in a dense forest, struggles to grow up to maturity, but the dense shade of the older and higher trees robs it of the necessary light. If it could only once grow as tall as the rest all would be easy, it would then get its fair share of light and sunshine. Thus it often occurs in the history of inventions that the surroundings are not favorable when the first attack is made, and that subsequently it is repeated by different persons, and finally in different circumstances it may eventually succeed and become established.

We may take in illustration almost any of the great inventions of undoubted utility of which we happen to have the full history—for instance, some of the great scientific discoveries, or some of the great mechanical inventions, such as the steam engine, the gas engine, the steamship, the locomotive, the motor car, or some of the great chemical or metallurgical discoveries. Are not most, if not all, of these the result of the long-continued labor of many persons, and has not the financial side been, in most cases, a very important factor in securing success?

The history of the steam engine might be selected, but I prefer on this occasion to take the internal-combustion engine, for two reasons—first, because its history is a typical one; and secondly, because we are to hear a paper by that able exponent and great inventor in the domain of the gas engine, Mr. Dugald Clerk, describing not only the history, but the engine in its present state of development and perfection, an engine which is able to convert the greatest percentage of heat units in the fuel into mechanical work, excepting only, as far as we at present know, the voltaic battery and living organisms.

The first true internal-combustion engine was undoubtedly the cannon, and the use in it of combustible powder for giving energy to the shot is strictly analogous to the use of the explosive mixture of gas or oil and air as at present in use in all internal-combustion engines; thus the first internal-combustion engine depended on the combination of a chemical discovery and a mechanical invention, the invention of gunpowder and the invention of the cannon.

In 1680 Huygens proposed to use gunpowder for obtaining motive power in an engine. Papin, in 1690, continued Huygens's experiments, but without success. These two inventors, instead of following the method of burning the powder under pressure, as in the cannon, adopted, in ignorance of the thermodynamic laws, an erroneous course. They exploded a small quantity of gunpowder in a large vessel with escape valves, which after the explosion caused a partial vacuum to remain in the vessel. This partial vacuum was then used to actuate a piston or engine and perform useful work. Subsequently several other inventors worked on the same lines, but all of these failed on account of two causes which now are very evident to us. First, gunpowder was then, as it still is, a very expensive form of fuel, in proportion to the energy liberated on explosion; secondly, the method of burning the powder to cause a vacuum involves the waste of nearly the whole of the available energy, whereas had it been burned under pressure, as in the cannon, a comparatively large percentage of the energy would have been converted into useful work. But even with this alteration, and however perfect the engine had been, the cost of explosives would have debarred its coming into use, except for very special purposes.

We come a century later to the first real gas engine. Street, in 1794, proposed the use of vapor of turpentine in an engine on methods closely analogous to those successfully adopted in the Lenoir gas engine of eighty years later, or thirty years ago. But Street's engine failed from crude and faulty construction. Brown, in 1823, tried Huygens's vacuum method, using fuel to expand air instead of gunpowder, but he also failed, probably on account of the wastefulness of the method.

Wright, in 1833, made a really good gas engine, having many of the essential features of some of the gas engines of the present day, such as separate gas and water pumps, and water-jacketed cylinder and piston.

Barnett, in 1839, further improved on Wright's design, and made the greatest advance of any worker in gas engines. He added the fundamental improvements of compression of the explosive mixture before combustion, and he devised means of lighting the mixture under pressure, and his engine conformed closely to the present-day practice as regards fundamental details. No doubt Barnett's engine, so perfect in principle, deserved commercial success, but either his mechanical skill or his financial resources were inadequate to the task, and the character of the patents would seem to favor this conclusion, both as regards Barnett and other workers at this period. Up to 1850 the workers were few, but as time went on they gradually increased in numbers; attention had been attracted to the subject, and men with greater powers and resources appear to have taken the problem in hand. Among these numerous workers came Lenoir, in 1860, who, adopting the inferior type of non-compression engine, made it a commercial success by his superior mechanical skill and resources. Mr. Dugald Clerk tells us: "The proposals of Brown (1823), Wright (1833), Barnett (1838), Bansanti and Matteucci (1857), show gradually increasing knowledge of detail and the difficulties to be overcome, all leading to the first practicable engine in 1866, the Lenoir." This stage of the development being reach-

ed, the names of Siemens, Beaudé, Roches, Otto, Dugald Clerk, Priestman, Daimler, Dowson, and others, appear as inventors who have worked and added something to perfect the internal-combustion engine and its fuel, and who have helped bring it to its present state of perfection.

In the history of great mechanical inventions there is perhaps no better example of the interdependence of the engineer, the physicist, and the chemist than is evinced in the perfecting of the gas engine. The physicist and the chemist together determine the behavior of the gaseous fuel, basing their theory data obtained from the experimental engines constructed by the mechanical engineer, who, guided by their theories, makes his designs and improvements, then, again, from the results of the improvement fresh data are collected and the theory further advanced, and so on until success is reached. Though I have spoken of the physicist, the chemist and the engineer as separate persons, it more generally occurs that they are rolled into one, or at most two, individuals, and that it is indispensable that each worker should have some considerable knowledge of all the sciences involved to be able to act successfully.

Now let us ask, Could not this very valuable invention, the internal-combustion engine, have been introduced in a much shorter time by more favoring circumstances, by some more favorable arrangement of the patent laws, or by legislation to assist the work attacking so difficult a problem? I think the answer is that a great deal might be done, and I will endeavor to indicate some changes and possible improvements.

The history of this invention brings before our minds two important considerations. First, let us consider the patentable matter involved in the invention of the gas engine, the utilization for motive power purposes of the then well known property of the explosive energy of gunpowder or of mixtures of gas and oil with air. Are not these obvious differences to persons of a mechanical turn of mind and who had seen guns fired, or explosions in battle containing spirits of turpentine when slightly heated and a light applied to the neck? Surely no fundamental patent could have been granted under existing patent laws for so obvious an application of known forces. Consequently, patent protection was sought in comparative details, details in some cases essential to success which were evolved or invented in the process of working out the invention. In the extended field of operations a slight protection was in some instances obtained. But in answer to the question whether such protection was commensurate with the benefits received by the community at large there can, I think, be only one reply. Generally those who did most got nothing, some few receiving insufficient returns, and in very few cases indeed can the return be said to have been adequate. The second important consideration is that of the method of procedure of the patentees, for it appears that very few of them had studied what had been suggested or done before by others before taking out their own patents. We are also struck by the number of really important advances that have been suggested and have failed to fructify, either from want of funds or other causes, to be forgotten for the time and to be re-invented later on by subsequent workers.

What a waste of time, expense, and disappointment would be avoided if we in England helped the patentee to find out easily what had been done previously; the lines adopted by the United States and German patent offices, who advise the patentee after the receipt of his provisional specification of the chief and anticipatory patents, dead or alive! And ought we in England to rest content to see our patentees awaiting the report of the United States and German patent offices on their foreign equivalent specifications before filing their English patent claims? Ought not our patent office to give more facilities and assistance to the patentee?

Before proceeding further to discuss some of the possible improvements for the encouragement and protection of research and invention, I ask you further to consider the position of the inventor—the man anxious to achieve success where others have hitherto failed. To be successful he must be something of an enthusiast; and usually he is a poor man, or a man of moderate means, and dependent on others for financial assistance. Generally, the problem to be attacked involves a considerable expenditure of money; some problems require a great expenditure before any return can thereby accrue, even in the most favorable circumstances. In the very few cases where the inventor has some means of his own they are generally insufficient to carry him through, and there have unfortunately been many who have lost everything in the attempt. In nearly all cases the inventor has to co-operate with capital; the capitalist may be a sleeping partner, or the capital may be held by a firm or syndicate, the inventor in such case being a partner—a junior partner—or a member of the staff. The combination may be successful and lasting, but unfortunately the best inventors are often bad men of business. The elements of the combination are often unstable, and the disturbing forces are many and active; especially is this so when the problem to be attacked is one of difficulty, necessitating various and successive schemes involving considerable expenditure, generally many times greater than that foreshadowed at the commencement of the undertaking. In such circumstances, unless the capitalist or board of the senior partner or board be in entire sympathy

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with the inventor or exercise great forbearance, stimulated by the hope of ultimate success and adequate returns, the case becomes hopeless, disruption takes place, and the situation is abandoned. Further, in the majority of cases, after some substantial progress has been made, it is found that under the existing patent laws insufficient protection can be secured, and the prospect of a reasonable return for the expenditure becomes doubtful. In such circumstances the capitalist will generally refuse to proceed unless the prospect of being first in the field may tempt him to continue.

Very many inventors, as I have said, avoid the expense of searching the patent records to see how far their problem has been attacked by others. In some cases the cost of a thorough search is very great indeed; sometimes it is greater than the cost of a trial attack on the problem. In the case of young and inexperienced inventors there sometimes exists a disinclination to enter on an expensive search; they prefer to spend their money on the attack itself. There are some, it is true, who have a foolish aversion to take steps to ascertain if others have been before them, and who prefer to remain in ignorance and trust to chance. It will, however, be said that the United States and German patent office reports ought to suffice to warn or protect the English patentee; but my own experience has been that such protection is not entirely satisfactory. There is, first, a considerable interval before such reports are received, and the life of a patent is short. Then, if the patent is upon an important subject, attracting general attention, the search is vigorous and sometimes overwrought, and the patent unjustly damaged or refused altogether. If, however, the patent is on some subject not attracting general attention, it receives too little attention and is granted without comment.

In some few instances it may be said that ignorance has been a positive advantage, and that if the patentee had realized how much of his patentable work was honeycombed by previous publications and patents, he would have lost heart and given up the task. It is, I think, a case of the exception proving the rule, and the patentee ought, as far as possible, in all cases to know his true position, and make his choice accordingly. The present patent law has some curious anomalies. Let us suppose some inventor has the good fortune to place the keystone in the arch of an invention, to add some finishing touch which makes the whole invention a complete success, and valuable. Then, success having been proved possible, others try to reap the results of his labor and good fortune, and, as often happens, it is discovered after laborious research that some one else first suggested the same key-stone in some long-forgotten patent or obscure publication, but for some reason or other the public were none the better for his having done so. What does the law do? It says this is an anticipation, and instead of apportioning to all parties reasonable and equitable shares in the perfected invention, to which no one could object, it says that the patent is injured or perhaps rendered useless by the anticipation, and that its value to everyone concerned is thereby diminished or destroyed, as the case may be, and thrown open to the public. Until a few years ago, any anticipations, however old, might be cited; but recently the law has been amended, and at present none rank as anticipations which are more than fifty years old.

The perfecting of inventions and their introduction into general use require capital, as we have seen—sometimes a considerable amount, as in the introduction of the Bessemer process for steel, or the linotype system of printing—before any commercial success can be realized.

Capital having been found, the next difficulty is in the conservatism of persons and communities who are the buyers of the invention. There is always present in their minds the risk of failure and its consequent loss and worry to themselves, and in the event of success the advantage, in their estimation, may not be sufficient to counterbalance the risk. In large departments and companies the management of which is conducted by officials receiving fixed salaries, acting under non-technical supervision, there is a strong tendency among the officials to leave well enough alone, the organization being such that the risk of failure, even though it be remote, more than counterbalances, in their estimation, the advantages that would result in the event of success. Next is the opposition of those who are financially interested in competing trades or older inventions; and if the invention is a labor-saving appliance, then the active opposition of the displaced labor is a serious, though generally only a temporary, barrier.

Fortunately, however, for the community, for research, and for invention, there is always to be found a considerable percentage of persons who, apart from the inventor, are able and willing to risk, and indeed to sacrifice, their personal interests in the cause of progress for the benefit of the community at large; and were it not for such persons the task of the introduction of most inventions would be an impossible one.

There are many problems of the highest importance in physics, engineering, chemistry, geology, and the arts, of which the investigation might probably prove of great benefit to the human race, and of which the probable monetary cost of the attack would be considerable, and of some very great indeed. Let us, then, inquire how the necessary funds could be raised. It is possible in the case of some of the more attractive problems that a group of rich philanthropists might

be found, but in most cases it would be impossible to form a company on business lines, under the existing laws of this and other countries, as I shall endeavor to show.

In the case of many of the problems, no patents will give adequate protection; in some cases there is no subject matter of novelty and importance involved. In other cases the probable duration of the investigation is so long that any initial patents would have expired before a commercial result was reached, and in either of these circumstances there would be no inducement to business men or financiers to undertake the risk.

As an illustration of my meaning I will take two investigations that have doubtless occurred to the minds of most of those present, though many others of greater or less importance might be cited. One is the thorough investigation of the problem of aerial navigation, with or without the assistance of flotation by gas. This problem could undoubtedly be successfully solved by an organized attack of skilled and properly trained engineers and the expenditure of a large sum of money. Assuming the problem solved, and commercially successful, it appears to be impossible under the existing patent laws to secure any adequate monopoly so as to justify the expectation of a reasonable return on the capital expended on the invention. For in view of the multitude of suggestions that have been made and the experiments that have been carried out, the practical solution of the problem would appear to rest on a judicious selection of old ideas by means of exhaustive experiments.

Another and perhaps more important investigation which has not, as yet, been attacked to any material extent is the exploration of the lower depths of the earth. At present the deepest shaft is, I believe, at the Cape, of a little more than one mile in depth, and the deepest bore-hole is one made in Silesia, by the Austrian government, of about the same depth. What would be found at greater depths is at present a matter for conjecture, founded on the dip and thicknesses of strata observed on or near the surface. Much money and many valuable lives have been devoted to exploration of the polar regions, but there can be no comparison between the scientific interest and the possible material results of such exploration and the one I have chosen for illustration of the inadequate protection afforded by law—namely, a great engineering attack on a problem of geology.

I would ask you to consider the commercial aspect of this engineering geological enterprise, as compared with exploration into new or unknown areas on the surface of the earth.

An exploring expedition into a new country has before it generally the probability of the acquisition of territorial and mineral rights or possessions bringing material gain to the undertakers. The rights of such enterprises are well known, and capital can be obtained with or without national support, as the case may be. On the other hand, the explorer into the depths of the earth has no rights or monopolies beyond the mineral rights of the land he has purchased over his boring; further, it is improbable that he can obtain any patent of substantial value for his methods of boring to great depths. To succeed in the undertaking a great expenditure of money must be incurred, an expenditure far greater than that of an exploring expedition, and analogous to that of a military expedition or a small invading army, and to raise this sum the pioneers have practically no security to offer. For if they succeed in finding rich deposits of precious minerals in greater abundance, or succeed in making some geological discovery associated with deep borings, they gain no exclusive title to these under existing laws. Any other person or syndicate acting upon the experience gained, could sink other shafts in other places or countries, and, benefiting by the experience gained by the pioneers, could probably carry out the work more advantageously, and thus depreciate the first undertaking or render it valueless, as has often occurred before.

Let us consider more closely some of the essential features of sinking a shaft to a great depth, for I think it will be seen that it presents no unsurmountable difficulties beyond those incidental to an enterprise of considerable magnitude involving the ordinary methods of procedure and the ordinary methods adopted by mining engineers. That there would be some departures from ordinary practice on account of the great depth is true, but these are more of the character of detail. On the design of this boring I have consulted Mr. John Bell Simpson, the eminent authority on mining in the north of England. The shaft would be sunk in a locality to avoid as far as possible water-bearing strata and the necessity of pumping. It would be of a size usual in ordinary mines or coal-pits. The exact position of such shaft would require some consideration as to whether it should commence in the primary or secondary strata. It would be sunk in stages, each of about half a mile in depth, and at each stage there would be placed the hauling and other machinery, to be worked electrically, for dealing with each stage. The depth of each stage would be restricted to half a mile in order to avoid a disproportionate cost in the hauling machinery and the weight of rope, as well as increased cost in the cooling arrangements arising from excessive hydraulic pressures. At each second or third mile in depth there would be air-locks to prevent the air-pressure from becoming excessive owing to the weight of the superincumbent air, which at from two to three miles would reach about double the atmospheric pres-

sure at the surface. A greater rise of pressure than this would be objectionable for two reasons—first, from the inconvenience of the workmen; secondly, from the rise of temperature due to the adiabatic compression of the circulating air for ventilating purposes. The air pressure immediately above each air-lock would thus reach to about two atmospheres, and beneath to one atmosphere. In order to carry on the transfer of air through the air-locks for ventilating purposes pumps coupled to air engines would be provided, the energy to work the pumps being obtained from electro-motors. To maintain the shaft at a reasonable temperature at the greater depth powerful means of carrying the heat to the surface would be provided.

The most suitable arrangement for cooling would probably consist of large steel pipes, an upcast and a downcast pipe, connected at the top and bottom of each half-mile section in a closed ring. This ring would be filled with brine, which by natural circulation would form a powerful carrier of heat; but the circulation, assisted by electrically-driven centrifugal pumps, would be capable of carrying an enormous quantity of heat upward to the surface. At each half-mile stage there would be a transfer of the heat from the ring below to the ring above by means of an apparatus similar in construction to a feed-water heater, or to a regenerator constructed of small steel tubes, through which the brine in the ring above would circulate, and around the outside the brine in the ring below could also circulate, the heat being transmitted through the metal of the tubes from brine ring to brine ring.

We have now presented to us two alternative arrangements for cooling. One arrangement would be to cool the brine to a very low temperature in the top ring at the mouth of the shaft by refrigerating machinery, so as to provide a sufficient gradation of temperature in the whole brine system, to insure the necessary flow of heat upward from brine ring to brine ring, and overcome all the resistances of heat-transfer, and so maintain the lowest ring at the temperature necessary for effectual cooling of the lowest section of the shaft. But a better arrangement would be to place powerful refrigerating machinery at certain of the lower stages, the function of this machinery being to extract heat from the ring below and deliver it to the ring above. This latter method would increase to a very great extent the heat-carrying power of the system, which in the first arrangement is limited by the freezing temperature of brine in the descending column and the highest temperature admissible in the ascending brine column. The amount of heat conducted inward through the rock-wall and requiring to be absorbed and transferred to the surface depends on the temperature and conductibility of the strata. But there is no doubt that the methods I have indicated would be capable of maintaining a moderate temperature in the shaft to a depth of twelve miles.

During the process of sinking at the greater depths the shaft bottom would require the application of a special cooling process in advance of the sinkers, similar to the Belgian freezing system of M. Poesche used for sinking through water-bearing strata and quick-sands, and now in general use. It consists in driving a number of bore-holes in a circle outside the perimeter of the shaft to be sunk; through these bore-holes very cold brine is circulated, thus freezing the rocks and quicksands and the water therein, and when this process is completed the sinking of the shaft is easily accomplished.

In our case this process would be maintained not only on the shaft bottom, but also for some time on the newly-pierced shaft sides, until the surrounding rock has been cooled for some distance from the face.

As to the cost, rate of boring, and normal temperature of the rock, an approximate estimate has been made, based on the experience gained on the Rand, but including the extra costs for air-locks and cooling:

	Cost	Time in Years	Temp. of Rock
For 2 miles depth from the surface	£ 500,000	10	122 deg. F.
" 4 "	1,100,000	25	151 "
" 6 "	1,800,000	40	182 "
" 8 "	2,700,000	55	212 "
" 10 "	3,700,000	70	243 "
" 12 "	5,000,000	85	272 "

I hope I have succeeded in showing in the short time at our disposal that an exploration to great depths is not an impossible undertaking. But my main object in discussing the enterprise at some length has been to show that a pioneer company would not acquire any subsequent monopoly of similar works under the existing patent laws or the laws of any country.

In the scheme as I have described it, there appears to be nothing that could be patented; but let us suppose that some good patent could have been found that was absolutely essential to the success of the undertaking, it would certainly have reaped any substantial return, and probably before the first enterprise had been completed. It follows therefore that at the present time there is no adequate protection, or indeed any protection at all, for the promoters of many great and important pioneer enterprises, some of which might prove of immense benefit to mankind.

Let us ask what change in the laws would place great pioneer research work on a sound financial basis. A government grant, except for very special purposes, seems to be out of the question, seeing that the benefits to be derived are generally not confined to any one country. An extension of the life of patents,

which is now from fourteen to sixteen years in different countries, would be undoubtedly a step in the right direction. It would be of great benefit generally if some scale of duration of patents could be fixed internationally, the scale being fixed according to the subject-matter, the difficulty of the attack, and the past history of the subject, but more especially in view of the utility of the invention.

One of the chief objections raised by the Privy Council against the extension of patents in this country has rightly been that undue prolongation is unfair to the British public, seeing that abroad no prolongations are granted. Therefore, if the duration of patents for important matters is to be extended at home it must also be extended abroad. In other words, such prolongations, to be effective, should necessarily extend to other countries. They should be international, and concurrent in all the countries interested.

One possible solution of this difficult question would be to place such matters under the jurisdiction of a central international committee, who would have the apportionment of the life and privileges of patents and of the extension or curtailment of their duration, according to their handling by the owners. I would ask, Why has a patent a life of only fourteen or sixteen years, while copyright is for forty-two years? Why has a pioneer company making a railway under act of Parliament generally rights forever unless it abuses its privileges, or the requirements of the district necessitate the construction of competing lines, while a patent has in comparison a life of infinite shortness?

I might also cite gas companies, electrical supply companies, under act of Parliament, or provisional orders of forty-two years' duration; and this reminds us of the fact that until the term of life for electric supply companies had been extended from twenty-one years to forty-two years by the bill of 1884, it was impossible to find capital for such undertakings.

Now, it may be urged that the grant of a patent is a different thing from the grant of power to a railway company, a gas or electric supply company. But the object of this address has been to show that a patent, to be fair to the patentee, ought in many cases to be analogous to an act of Parliament or a provisional order. Would it not place matters in a fairer position, especially in the case of expensive and lengthy researches, to grant to those who pledge themselves to spend a suitable and minimum sum within a stated period on the research a reasonable and fair monopoly, so that such person or syndicate might in the event of success be in the position to reap a reasonable return for their expenditure and risk?

Some such measure would unquestionably give an immense stimulus to research and invention by enabling capital to be raised and works started on commercial lines in fields of great promise at present almost untouched.

I pass over the disadvantages to the British inventor of the hostile patent tariffs of Continental nations and of the protective patent laws of some of the British dependencies, disadvantages greater than those imposed by protective tariffs on the ordinary British manufacturer.

There is, however, another aspect of the question to which I would briefly allude: it is the great benefits that the world at large has derived from the work of inventors in the past.

Think of the multitude and power of the great steam engines and gas engines that drive our factories, and pump the water out of our mines, and supply our cities with water, light, and power; of the great steamships scattered over the ocean and the locomotives on the railways.

Think of the billions of tons of steel that have been made by the Bessemer, Siemens-Martin, and Thomas Gilchrist processes, and of the great superiority and less cost of the material over the puddled iron which it superseded.

Think of the vast work performed by the electric telegraphs and telephones; and we must not fail to include the great chemical and metallurgical processes carried on all over the world, besides the countless other inventions and labor-saving appliances. Can we form any idea of the commercial value of all these gigantic tools that past inventors have left as a heritage to the human race, and can we venture to place any order of magnitude on so vast a sum?

If we take as our unit of value the whole of the money spent on all inventions, both successful and unsuccessful, I think we shall be much below the mark if we assume that the value of the benefits has on the average exceeded by ten-thousandfold the money spent on making and introducing the inventions.

If this is so, let us see what it means. It means that for every unit of capital spent by the inventors and their friends on invention they have in some cases received nothing back. In some cases they have just got their capital back, in some cases two or three-fold, occasionally tenfold, very rarely a hundredfold. Whereas the world at large has received a present of ten-thousandfold greater value than all the money spent and misspent by the small band of past inventors.

In conclusion, let us hope that the inventor will in the future receive more encouragement and support, that the patent laws will be further modified and extended, that the people at large will consider these matters more closely and recognize that they are of first importance to their progress and welfare, and that in the future it may be easier, nay in some cases

possible, to carry on many great researches into the secrets of nature.

[Concluded from SUPPLEMENT No. 1503, page 2408.]
MODERN METHODS OF STEEL CASTING.*

By JOSEPH HORNER, A.M.I.Mech.E.

THOSE who are unfamiliar with foundry work may be surprised to learn that sand in cores and molds will interfere very greatly with the shrinkage of steel, and in a lesser degree with that of iron also. I have seen more than one large pipe, or cylinder, fractured in consequence of neglect to loosen the core in time; and

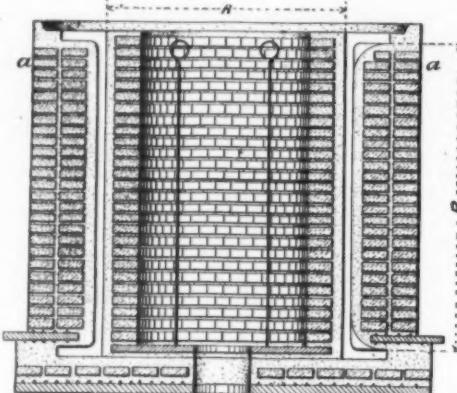


FIG. 16.—A BRICKED-UP LOAM MOLD (WITH COPE REMOVED) TO ILLUSTRATE RESISTANCE TO SHRINKAGE.

flanges torn off long pipes, due to resistance of the sand behind them. Fig. 16 represents a cylinder, or a large inlet pipe made in loam by bricking up. If this were cast in steel or iron, and left to cool without any precautions being taken, it would fracture across its diameter, *A*, and also between its flanges, *B*. This is prevented by laying, between the hard bricks, three or four courses of bricks made of dried loam, from top to bottom of the central core; and two or three horizontal courses of the same, around the top at *a*, underneath the flange. The flanges are also frequently stiffened with brackets, as shown in the right-hand side. The loam bricks, in some cases, are left to yield and be crushed by the shrinking cylinder. In others they are dug out of the mold as soon as the casting has fairly set, but while still red hot; this is necessary in thin pipes.

In the pipe, Fig. 17, the hard dried sand at *a* will prevent the shrinkage of the flanges with the pipe, and here, too, the sand must be loosened, and partly dug away before the metal cools. Brackets are also often cast on as shown at the left hand, as a source of strength. In Fig. 11, if cast in steel, the interior sand should be loosened and a portion dug away; the same thing should be done just behind the flanges of Figs. 12 and 13.

The effect of mass on shrinkage is often learned from accidental fractures and wastes. A stout casting will resist shrinkage strains to which a thinner one would succumb; so that the question of easing a mold, or of stiffening a casting with brackets, or radii, becomes closely related to the mass of the metal. Thus, a cylinder (Fig. 16), if 2 inches thick, would be twice as strong to resist shrinkage stresses as one only 1 inch thick. The reason lies mainly in the extra strength, and correspondingly greater elasticity, of the metal. But, besides this, there is a difference due to the more rapid chilling effect which takes place on thin than on thick metal. The chill penetrates quickly in thin, with consequent hardening, rapid setting, and brittle tendencies—evils to be avoided in castings.

That the importance of shrinkage is not exaggerated, may be seen from a moment's consideration. Say it amounts to $\frac{1}{4}$ inch per foot; that, on a casting only

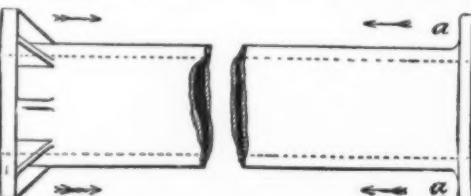


FIG. 17.—PIPE FLANGES WHICH ARE LIABLE TO FRACTURE.

6 feet in dimensions, would equal $1\frac{1}{2}$ inches. If this is hindered, clearly the casting must stretch to that extent, which is impossible; or it must do the other thing—fracture.

Fig. 18 shows the difference between a safe and an insecure design. Above the line *a* the design is suitable for cast iron, but unsafe in steel, which would be "drawn," as indicated. Taking out a considerable amount of metal at *b* renders the design nearly uniform in section.

Wheels and wheel centers are cast in large numbers in steel. One example, Fig. 19, will illustrate the differences already noted in other castings. The lower portion of the figure is a design suitable for iron; the

upper is suitable for steel, having strong arms, larger radii, and a thinner boss and rim. Provided they are well proportioned, these wheels seldom give much trouble, as they are mostly below 2 feet 6 inches in diameter.

Casting parts together not only interferes with shrinkage, but often causes a thickening of the metal in angles, quite sufficient in amount to cause sponginess like that shown in Fig. 15. Though this alone may not be sufficient to cause immediate fracture, or to produce incipient cracks, the open porous metal is a perpetual, but hidden menace when under strain; while in castings subject to fluid pressure it is a cause of leakage.

To cast big lugs, bosses, and brackets on otherwise plane framings, which can be done in iron, is most judicious in steel, for they will distort the casting in the most favorable circumstances; while in bad cases they cause incipient cracks, or even absolute fracture. Fig. 20 illustrates a design which, cast in steel, gave much trouble. It is a brake ring cast on the arms of a toothed wheel, and it produced much distortion. This was got over by casting the ring separately, and bolting it up to a circular facing, Fig. 21. It involved extra work in the turnery, but was a good job.

A very important difference between casting steel and iron is seen in the cross sectional area of the ingates, and runners required. Steel cannot be poured safely through ingates so small as those which are used in iron, because the metal is liable to congeal before the mold is filled; hence the reason for the enormous ingates seen in Figs. 2, 10, and 14. The following is the explanation of the difference in steel and iron in this respect. Pig-iron is fluid in proportion approximately to the amount of free carbon that it contains, a fact which is strikingly apparent in the difference between gray iron and the mottled and white iron. A white iron, in which the whole of the carbon is combined, and a mottled iron, in which a considerable proportion of this element is in the combined condition are both much more sluggish than gray iron, which contains its carbon in the graphitic or free state. This difference is apparent both in the ladle, and in pouring. Steel low in carbon approximates to the condition of white iron, and to that of viscous wrought iron; hence the difficulty of pouring it in thin sections. Steel "chilling" quickly, fails to fill a mold properly, unless large deep runners are used—large, to fill the mold quickly, and deep, to afford pressure, or "head" to the metal. Taking an extreme example, it would be impossible to pour either steel, white pig-iron, or heavily mottled iron, into the molds for rain-water pipes;

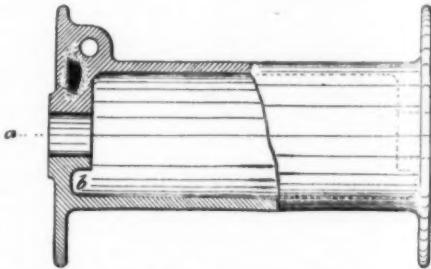


FIG. 18.—DESIGN FOR IRON (ABOVE) AND FOR STEEL (BELOW).

neither would be fluid enough to fill such molds. Only the grayest iron, containing about 4 per cent of graphite carbon, will fill such thin molds.

But the filling of a mold is only one of the reasons why large ingates are used. A large, deep ingate acts as a "shrinkage head," or "sullage head"—the "head metal" of the molder. The mass of hot metal in it affords a supply to the shrinking mass of the casting below, and itself retains the sullage or dirt, the light and impure metal that would otherwise go down into the mold. The steel caster makes use of very large shrinkage heads—much bigger than the iron founder requires, but with the same objects in view. In many steel castings (e.g., solid pinions, stamps, etc.), there is as much head as casting, or more; and it is only by the adoption of this device that sound metal can be obtained. The heads are sawn, or turned off, and they contain the light, open, spongy, dirty metal, while the castings receive only the sound metal. The large heads, indicated in Figs. 2, 10, and 15, may have from six to eight times the sectional area of those used on iron castings of similar form.

But the remedy of a big head will be worse than the evil it is designed to correct, unless it is applied with judgment. A great mass of metal, as we have pointed out, shrinks beyond the normal, and distorts adjacent parts. Heads are therefore put on the more massive portions of castings; never on a slender rim, or arm, or plate. If this is not practicable, then several smaller heads or runners must be substituted, which is frequently done.

Steel castings are subject, in a much greater degree than those of cast iron, to two other evils—intense hardness, especially on and near the surface, and to blow-holes, and general sponginess. Both these evils were very pronounced in the early days of steel casting, so that between these, and excessive distortion, many castings had to be scraped. Intense hardness is reduced by annealing. The sponginess is lessened by the practice of casting good heads on, and dead melting of the metal. Thin castings generally suffer more from blow-holes than thicker ones do. As these holes

are mostly below the surface, they are seldom discovered until surfaces are being planed or turned. Steel frays frequently, for this reason, rough-tool doubtful castings before sending them to their customers. Slight honeycombing in some non-vital parts of steel castings should not be allowed to condemn them. It is generally practicable to secure sound metal in vital portions by casting those downward.

Annealing consists in exposing castings for several days (more or less) to temperatures of from 800 to 900 deg. C., according to the mass of metal, and the percentage of carbon present; and then cooling them gradually. In this way the castings are rendered tough, internal strains are relieved, and they are easier to tool. If tested, the ultimate strength is found to be lessened, but the elongation, and contraction of area, are increased; in short, the castings are much better suited for working on, and for constructional purposes, than they would be if used just as they are turned out of the sand.

There are three methods of melting steel for foundry use—in crucibles, Bessemer converters, and open-hearth furnaces. Each system includes a field so immense that our remarks relating to them must be very brief, and absolutely restricted to their bearings on the particular subject of this paper.

The case of some very small castings excepted, crucible steel-work, in England, is confined mostly to the manufacture of cutlery steel from raw blister bars, which are broken up and melted in crucibles, in order to render the metal homogeneous. Small castings made in this way are expensive. Yet, at Krupp's, in Essen, big cannon have been cast from crucible steel for eighty years past, the product of several hundred crucibles being used for casting a single gun. The great advantage of this method of casting is that an exact chemical composition can be insured, because the contents of the closed crucible suffer no contamination from without. Whatever the mixture is that goes in, the same comes out, and, therefore, though costly, it is a trustworthy process. But it is used only to a slight extent for ordinary castings.

The second method is that of the Bessemer converter. Here the molten pig, emptied from the cupola into

The superiority of the metal produced in the open-hearth and the crucible to that in the converter is mainly due to the element of time, which enables the caster to more thoroughly oxidize the impurities, and to more quickly recharge the bath of metal.

For shells, wheel centers, trolley wheels, and the harder class of castings, the Bessemer answers well; but for electrical work, slenderly proportioned castings,

vantage that several blows can be obtained in a day against one only in an open-hearth furnace. As little as ten hundredweight of metal can be produced at a time in a Tropenas converter, against, say, five or six or eight tons in an open-hearth furnace. For small shops this is a great point in favor of the new methods. The small converter, or "Baby Bessemer," is also a valuable ally to the open-hearth plant; the first for small castings, and the second for the ordinary run of large work.

The Tropenas system has been in use at the works of Edgar Allen & Co., Ltd., of Sheffield, since 1892. Twenty of these plants, with fifty converters, are running in Europe; and nine plants, with thirteen converters, in the United States and Canada. With regard to one of these, the statement was recently made that over 700 blows had been made without a hitch occurring.

The system of multiple molding—that is, of casting superimposed molds—has been adopted with much success in small steel castings, weighing from a few ounces to a few pounds. As many as 500 small castings have been made in this way at one pouring in multiple molds.

The Tropenas process, while adapted primarily to the making of small castings weighing from a few pounds to a ton or so, is also adaptable to heavier work in the absence of an open-hearth plant. This is done by collecting the steel of several blows in a ladle, from two converters alternately, a "heat" occupying about twenty minutes. Castings of several tons weight can be made with metal which has been standing in the ladle for two hours, due to the high temperature and fluidity obtainable by the process.

The relative positions of the three furnaces used, the crucible, the Bessemer, and the open hearth, may be concisely summarized thus:

The crucible method is suitable for the production of small castings, but its high cost relatively to the weight of castings produced, precludes its extended use commercially. When cost is no object, crucible steel has been used for the biggest ordnance made. The Bessemer converter is suitable alike for large and small castings; but one difficulty is that all the matter must be tapped quickly, which is often inconvenient, and is not suitable at all for small work; further, the metal soon becomes sluggish, and there is great risk of "wasters" in consequence of the metal not filling thin sections of molds. Absolute uniformity of the metal is also not to be depended on. The open-hearth furnaces are capable of producing steel of a very uniform quality; but with this exception they share in the objections to the Bessemer converter. The whole of the metal—six or eight tons or more—must be tapped at once; and therefore is not suitable for small castings. It answers admirably for large castings, and is the furnace most generally employed.

The design of many large ladles used for pouring steel is similar to those used for filling ingot molds. Iron and brass founders invariably pour from the lip of the ladle, taking the metal therefore from the top. The steel founder more often pours from the bottom of the ladle, taking the metal from the locality where it is most dense. The metal by the Tropenas process can be poured perfectly fluid from the lip of a ladle, and the castings do not require to be annealed.

As the shrinkage of iron, though variable, is less than half that of steel, averaging $\frac{1}{2}$ inch in 15 inches, it follows that often the same patterns cannot be used for the two classes of molds. There are cases in which a difference of dimensions in small articles matters little, as (say) in truck or trolley wheels. But in others, as in gear wheels, brackets, cheeks, or frames that carry bearings required at exact centers or "overall" dimensions to fit other parts, separate patterns must be made if the castings are to be produced, sometimes in iron, sometimes in steel. There is often real economy in making two patterns, because weight can be lessened in steel, either to give equal strength with that of iron, or an excess of strength. Apart from this economy, it is better from the point of view of good design, to modify the proportions of adjacent parts for iron and steel respectively, on the lines which I have endeavored to make clear in the foregoing paragraphs.

The amount of shrinkage of steel, though always large, is variable, which sometimes causes trouble in castings made from the same patterns. Castings also turned out in one foundry may measure larger or smaller than those ordered from another, or differences will occur in the same foundry at different periods. This is due to variations in the chemical constitution of the metal, and to variations in the temperature at which it is poured; since the hotter the metal is, the more it has to shrink in the cooling.

DEEP ENGLISH MINES.

WITH increased and increasing demand for coal came the necessity for opening the lower seams, and deeper shafts meant heavier capital expenditures in colliery enterprise. It is worthy of remark how little the outside public realize of the great difficulties that often have to be overcome in sinking—such as passing through water-bearing strata or running sands—or of the enormous cost entailed by some colliery developments. As early as 1829 John Buddle, in giving evidence before the House of Lords, declared that the cost of sinking, even then, was frequently \$50,000 to \$75,000, and J. T. Taylor stated before a select committee on rating of mines in 1857 at Haswell colliery, in the County of Durham, \$200,000 was expended in contending with a quicksand, and that the shaft had ultimately to be abandoned. At Murton colliery, a few miles distant from Haswell, \$1,500,000 was expended

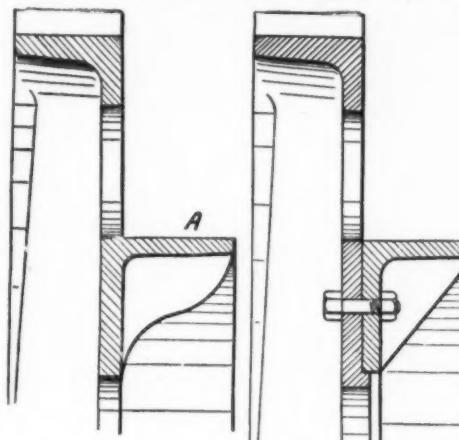


FIG. 20.—A DESIGN WHICH DISTORTS AND STRAINS A CASTING IN STEEL.

rudder frames, and propeller blades, and bosses, stern frames, and those in which a high degree of ductility is required, the open hearth is more suitable.

The Bessemer and open-hearth processes, therefore, practically divide between them the production of metal for the steel foundries. But specialization and improvement have always been busy around these main operations, and we must as briefly as possible explain how the practice of steel casting is being modified at the present time.

Although the Bessemer process is now carried out substantially as it was forty years ago, numerous improvements have been effected in the mechanical details of the work. One alone concerns us here; that, namely, of the adaptation of converters to the wants of the makers of small steel castings. The common converters are well adapted for massive work, but the metal is not hot or fluid enough if used in small charges.

The most recent advance in this direction is the Tropenas process, in which a high temperature, and great fluidity, are obtained by a method of surface oxidation; that is, the blast is caused to act upon the surface of the metal, instead of being forced into or through it. The converter bottom is made in the form of an inverted truncated cone, so offering a large upper surface for oxidation. The metal is taken from the converter direct, and that which remains retains its heat until required. The sectional diagrams (Fig. 22) illustrate the action of the Tropenas converter during the first and second blows. There are two rows of tuyeres, a lower and an upper. The lower tuyeres are termed "tuyeres of reaction," because the direct action of the air blown through them is on the surface of the molten metal, causing the upper layer to be directly oxidized. The gases which come off as a result are then burned, the upper row of tuyeres (the "tuyeres of combustion") being brought into operation by tilting the converter. The high temperature produced in this operation is beneficial. At the same time air is blown

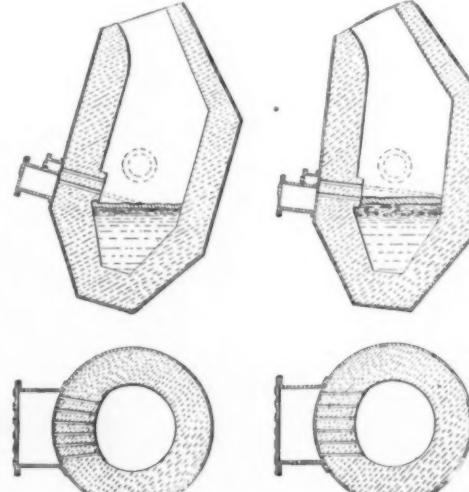


FIG. 21.—AVOIDED BY CASTING RING SEPARATE FROM WHEEL.

by the lower tuyeres through the loose slag formed on the surface.

The Robert process, and the Walrand Legéniel processes arrive at the same end by different designs and methods, and it appears that steel equal in quality to that produced in the open hearth is produced in these small converters; besides which there is the great ad-

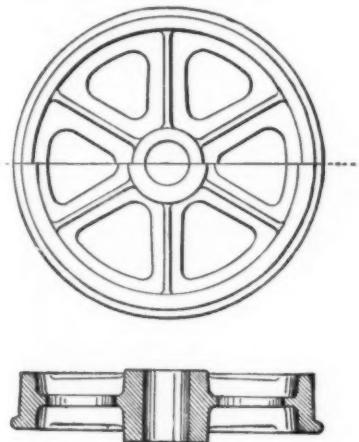


FIG. 19.—DESIGN FOR IRON AND FOR STEEL.

the converter, has its impurities burned out by the action of the oxygen in the air blast which is forced through the metal. The sulphur, manganese, silicon, and carbon are thus oxidized, and a nearly pure iron left, in a quiescent state; carbon and manganese are added in the exact proportions required, in the form of alloys of these elements with iron, as spiegeleisen or as ferromanganese.

It is not difficult to understand the weak points of this process, which were for a time so serious that they well-nigh wrecked the Bessemer invention. One difficulty is, that of recharging the metal with the precise quantity of carbon and manganese necessary; the other is the impossibility of oxidizing phosphorus in a converter unless lime is added to the charge to form a basic compound therewith. The anxieties and labors which have beset inventors in connection with these two difficulties are writ large in the history of steel-making. The elimination of phosphorus gives by far the greatest trouble, and it explains why British steel-makers have to bring half the ores they use from abroad, chiefly from Bilbao.

To overcome the difficulties inseparable from the Bessemer process, was the object of the open-hearth methods. Briefly, these contain provisions in the linings of the furnaces for deoxidizing the crude metal, in a process sufficiently prolonged to enable the melters to grade the degree of purity of the metal exactly. During the process, samples are taken and subjected to a rough analysis, and not until the precise proportions of metalloids desired are secured is the steel tapped from the furnace. The principle of operation is identical with that in the converter; that is, the foreign elements are first burned out, and the carbon and manganese then added in alloyed forms. Acid and basic linings are also employed. But the ultimate product is under more perfect control, resembling in this respect that melted in crucibles. But while the crucible holds a hundredweight or two, the open-hearth furnace deals with several tons; and if the product is not quite so superfine as that of the crucibles, it is capable of minute regulation, measured in a few tenths, say, of 1 per cent of metalloids.

in sinking; the quantity of water pumped during the operation of passing through the overlying magnesium limestone bed amounted to an average of 9,306 gallons a minute from a depth of 540 feet; and the three shafts ultimately reached the Hulton seam, at a depth of 1,488 feet from the surface, in April, 1843. Many deep and costly sinkings—several much deeper than in the last instance—have been put down since the Murton winning, but none, we believe, at a greater expenditure of capital, owing, doubtless, to the greatly improved methods now employed in carrying on such operations through watery strata—notably the Kind-Chaudron system, whereby the shaft is bored out and the side protected by metal cylinders lowered from the surface; and the Poetsch and Goberat methods, whereby the water is frozen in the "running" sand or the other water-bearing stratum, and the shaft sunk through the solid mass.—Engineering Magazine.

THE EVOLUTION OF THE SCIENTIFIC INVESTIGATOR.*

AMONG the tendencies characteristic of the science of our day is one toward laying greater stress on questions of the beginning of things, and regarding a knowledge of the laws of development of any object of study as necessary to its complete understanding in the form in which we find it. It may be conceded that the principle here involved is as applicable in the broadest field of thought as in the special research into the properties of the minutest organism. It therefore seems meet that the comprehensive survey of the realm of knowledge on which we are about to enter should begin by seeking to bring to light those agencies which have brought about the remarkable development of that realm to which the world of to-day bears witness. The principle in question is recognized in the plan of our proceedings by providing for each great department of knowledge a review of its progress during the century that has elapsed since the great event which the scene around us is intended to commemorate. But such reviews do not make up that general survey of science at large which is necessary to the development of our theme, and which must include the action of causes that had their origin long before our time. The movement which culminated in making the nineteenth century ever memorable in history is the outcome of a long series of causes, acting through many centuries, which are worthy of being brought into especial prominence on such an occasion as this. In setting them forth we should avoid laying stress on those visible manifestations which, striking the eye of every beholder, are in no danger of being overlooked, and search rather for those agencies whose activities underlie the whole visible scene, but which are liable to be blotted out of sight by the very brilliancy of the results to which they have given rise. It is easy to draw attention to the wonderful qualities of the oak; but from that very fact, it may be needful to point out that the real wonder lies concealed in the acorn from which it grew.

Our inquiry into the logical order of the causes which have made our civilization what it is to-day will be facilitated by bringing to mind certain elementary considerations—ideas so familiar that setting them forth may seem like citing a body of truisms—and yet so frequently overlooked not only individually, but in their relation to each other, that the conclusion to which they lead may be lost to sight. One of these propositions is that psychical rather than material causes are those which we should regard as fundamental in directing the development of the social organism. The human intellect is the really active agent in every branch of endeavor—the *primum mobile* of civilization—and all those material manifestations to which our attention is so often directed are to be regarded as secondary to this first agency. If it be true that "In the world is nothing great but man; in man is nothing great but mind," then should the keynote of our discourse be the recognition at every step of this first and greatest of powers.

Another well-known fact is that those applications of the forces of nature to the promotion of human welfare which have made our age what it is are of such comparatively recent origin that we need go back only a single century to antedate their most important features, and scarcely more than four centuries to find their beginning. It follows that the subject of our inquiry should be the commencement, not many centuries ago, of a certain new form of intellectual activity.

Having gained this point of view our next inquiry will be into the nature of that activity, and its relation to the stages of progress which preceded and followed its beginning. The superficial observer, who sees the oak but forgets the acorn, might tell us that the special qualities which have produced such great results are expert scientific knowledge and rare ingenuity, directed to the application of the powers of steam and electricity. From this point of view the great inventors and the great captains of industry were the first agents in bringing about the modern era. But the more careful inquirer will see that the work of these men was possible only through a knowledge of laws of nature which had been gained by men whose work took precedence of theirs in logical order, and that success in invention has been measured by completeness in such knowledge. While giving all due honor to the great inventors, let us re-

member that the first place is that of the great investigators whose forceful intellects opened the way to secrets previously hidden from men. Let it be an honor and not a reproach to these men that they were not actuated by the love of gain, and did not keep utilitarian ends in view in the pursuit of their researches. If it seems that in neglecting such ends they were leaving undone the most important part of their work, let us remember that nature turns a forbidding face to those who pay her court with the hope of gain, and is responsive only to those suitors whose love for her is pure and undefiled. Not only is the special genius required in the investigator not that generally best adapted to applying the discoveries which he makes, but the result of his having sordid ends in view would be to narrow the field of his efforts, and exercise a depressing effect upon his activities. It is impossible to know what application knowledge may have until after it is acquired, and the seeker after purely useful knowledge will fail to acquire any real knowledge whatever.

We have here the explanation of the well-known fact that the functions of the investigator of the laws of nature, and of the inventor who applies these laws to utilitarian purposes are rarely united in the same person. If the one conspicuous exception which the past century presents to this rule is not unique, we should probably have to go back to Watt to find another. The true man of science of to-day and of all past time has no such expression in his vocabulary as useful knowledge. His domain is the whole of nature, and were he to attempt its division into the useful and the useless, he would drop from his high estate.

It is, therefore, clear that the primary agent in the movement which has elevated man to the masterful position he now occupies is the scientific investigator. He it is whose work has deprived plague and pestilence of their terrors, alleviated human suffering, girdled the earth with the electric wire, bound the continent with the iron way, and made neighbors of the most distant nations. As the first agent which has made possible this meeting of his representatives, let his evolution be this day our worthy theme.

It has been said that the scientific investigator is a new species of the human race. If this designation is applicable to a class defined only by its functions, then it is eminently appropriate. But the biologist may object to it on the ground that a species, or even a variety, is the product of heredity, and propagates only or mainly its own kind. The evolutionist may join hands with him on the ground that only new faculties, not new modes of activity, are to be regarded as products of evolution, but let us not stop to dispute about words. We have no need of the term "species" in our present course of thought; but to deny the term evolution to the genesis of previously non-existent forms of intellectual activity is to narrow our conception of the course of nature, and draw a line of demarcation where no tangible boundary exists.

I am the more ready to invite your attention to the evolution of the scientific investigator, not only because the subject is closely correlated with human evolution in general, but because it is one branch of evolution which seems to me not to have received due prominence in discussions of the subject.

In our time we think of the process of development in nature as one going continuously forward through the combination of the opposite processes of evolution and dissolution. The tendency of our thought has been in the direction of banishing cataclysms to the theological limbo, and viewing nature as a sleepless plodder, endowed with infinite patience, waiting through long ages for results. I do not contest the truth of the principle of continuity on which this view is based. But it fails to make known to us the whole truth. The building of a ship from the time that her keel is laid until she is making her way across the ocean is a slow and gradual process; yet there is a cataclysmic epoch in her history, opening up a new era in her existence. It is the moment when, after lying for months or years a dead, inert, immovable mass, she is suddenly endowed with the power of motion and, as if imbued with life, glides into the stream, soon to begin a career of restless activity, of which the only bounds are those of the ocean. I think it is thus in the development of humanity. Long ages may pass during which a race, to all external observations, appears to be making no real progress. Additions may be made to learning, and the records of history may constantly grow, but there is nothing in its sphere of thought or in the features of its life that can be called radically new. Yet, nature may have been all along slowly working in a way which evades our scrutiny until the result of her operations suddenly appears in a new and revolutionary movement, carrying the race to a higher plane of civilization.

It is not difficult to point out such epochs in human progress. The greatest of all, because it was the first, is one of which we find no record either in written or geological history. It was the epoch when our progenitors first took conscious thought of the morrow, first used the crude weapons which nature had placed within their reach to kill their prey, first built a fire to warm their bodies and cook their food. I love to fancy that there was one first man, the Adam of evolution, who did all this, and who used the power thus acquired to show his fellows how they might profit by his example. When the members of the tribe or community which he gathered around

him began to conceive of life as a whole—to include yesterday, to-day, and to-morrow in the same mental grasp—to think how they might apply the gifts of nature to their own uses—a movement was begun which should ultimately lead to civilization. Many indeed, must have been the ages required for the development of this rudest primitive community into the civilization revealed to us by the most ancient tablets of Egypt and Assyria. After spoken language was developed, and after the rude representation of ideas by visible marks drawn to resemble them had long been practised, some real Cadmus must have invented an alphabet. When the use of a written language was thus introduced, the word of command ceased to be confined to the range of the human voice, and it became possible for master minds to extend their influence as far as a written message could be carried. Then were communities gathered into provinces, provinces into kingdoms, and kingdoms into the great empires of antiquity. Then arose a stage of civilization which we find pictured in the most ancient records—a stage in which men were governed by laws that were perhaps as wisely adapted to their conditions as our laws are to ours—in which the phenomena of nature were rudely observed, and striking occurrences in the earth or in the heavens recorded in the annals of the nation.

Vast was the progress of knowledge during the interval between these empires and the century preceding that in which modern science began. Yet, if I am right in making a distinction between the slow and regular steps of progress, each growing naturally out of that which preceded it, and the entrance of the mind at some fairly definite epoch into an entirely new sphere of activity, it would appear that there was only one such epoch during the entire interval. This was when abstract geometrical reasoning commenced, and astronomical observations aiming at precision were recorded, compared, and discussed. Closely associated with it must have been the construction of the forms of logic. The radical difference between the demonstration of a theorem of geometry and the reasoning of every-day life, which the masses of men must have used from the beginning, and which few even to-day ever get beyond, is so evident at a glance that I need not dwell upon it. The principal feature of this advance is that by one of those antinomies of the human intellect of which examples are not wanting even in our own time, the development of abstract ideas among the Greeks preceded the concrete knowledge of natural phenomena. When we reflect that in the geometry of Euclid the science of space was brought to such logical perfection that even to-day its teachers are not agreed as to the practicability of any radical improvement upon it, we cannot avoid the feeling that a very slight change in the direction of the intellectual activity of these people would have led to the beginning of natural science. But it would seem that the very purity and perfection which was aimed at in their system of geometry stood in the way of any extension or application of its methods and spirit to the field of nature. One example of this is worthy of attention. In modern teaching the idea of magnitude as generated by motion is freely introduced. A line is described by a moving point; a plane by a moving line; a solid by a moving plane. It may, at first sight, seem singular that this conception finds no place in the Euclidian system. But we may regard the omission as a mark of logical purity and rigor. Had the real or supposed advantages of introducing motion into geometrical conceptions been suggested to Euclid, we may suppose him to have replied that the theorems of space are independent of time; that the idea of motion necessarily implies time, and that, in consequence, to avail ourselves of it would be to introduce an extraneous element into geometry. The result was that, in keeping this science pure from ideas which did not belong to it, it failed to form what might otherwise have been the basis of physical science. Its founders missed the discovery that the methods of geometric demonstration could be extended into other fields and wider fields than that of space. Thus not only the development of applied geometry, but the reduction of other conceptions to a rigorous mathematical form was indefinitely postponed.

The idea of continuous increase in time is that by which the conceptions of the infinitesimal calculus can most easily find root in the mind of the beginner. It is quite possible that the contempt of the ancient philosophers for the practical application of their science, which has continued in some form to our own time, and which is not altogether unwholesome, was a powerful factor in preventing the development of this idea.

Astronomy is necessarily a science of observation pure and simple, in which experiment can have no place except as an auxiliary. The vague accounts of striking celestial phenomena, handed down by the priests and astrologers of antiquity, were followed in the times of the Greeks by observations having, in form at least, a rude approach to precision, though nothing like the degree of precision that the astronomer of to-day would reach with the naked eye, aided by such rude instruments as he could fashion from the tools at command of the ancients.

The rude observations commenced by the Babylonians were continued with gradually improving instruments, first by the Greeks and then by the Arabians; but the results failed to afford any insight into the true relation of the earth to the heavens. What was

* Opening address of the president of the International Congress of Arts and Science, at the St. Louis Exposition, September 19, 1904.

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most remarkable in this failure is that to take a first step forward, which would have led on to success, no more was necessary than a course of abstract thinking vastly easier than that required for working out the problems of geometry. That space is infinite is an unexpressed axiom, tacitly assumed by Euclid and his successors. Combining this with the most elementary consideration of the properties of the triangle, it would be seen that a given body of any size could be placed at such a distance in space as to appear to be like a point. Hence a body as large as our earth, which was known to be a globe from the time that the ancient Phenicians navigated the Mediterranean, if placed in the heavens at a sufficient distance, would look like a star. The obvious conclusion that the stars might be bodies like our globe, shining either by their own light or by that of the sun, would have been a first step to an understanding of the true system of the world.

There is historic evidence that this deduction did not wholly escape the Greek thinkers. It is true that the critical student will assign little weight to the current belief that the vague theory of Pythagoras that fire was at the center of all things, implies a conception of the heliocentric theory of the solar system. But the testimony of Archimedes, confused though it is in form, leaves no serious doubt that Aristarchus of Samos not only propounded the view that the earth revolves both on its own axis and around the sun, but that he correctly removed the great stumbling-block in the way of this theory by adding that the distance of the fixed stars was infinitely greater than the dimensions of the earth's orbit. Even the world of philosophy was not yet ready for this conception, and so far from seeing the reasonableness of the explanation, we find Ptolemy arguing against the rotation of the earth on grounds which careful observations of the phenomena around him would have shown to be ill founded.

Physical science, if we can apply that term to an uncoordinated body of facts, was successfully cultivated from the earliest times. Something must have been known of the properties of metals, and the art of extracting them from their ores must have been practised from the time that coins and medals were first stamped. The properties of the most common chemical compounds were discovered by alchemists in their vain search for the philosopher's stone, but no actual progress worthy of the name rewarded the practitioners of the black art.

Perhaps the first approach to a correct method was that of Archimedes who, after careful thinking, worked out the law of the lever, reached the conception of the center of gravity, and demonstrated the first principles of hydrostatics. It is, therefore, all the more remarkable that he did not extend his researches into the phenomena of motion, whether spontaneous or produced by force. The stationary condition of the human intellect was most strikingly illustrated by the fact that not until the time of Leonardo was any substantial advance made on his discovery. To sum up in one sentence the most characteristic feature of ancient and medieval science, we see a notable contrast between the precision of thought implied in the construction and demonstration of geometrical theorems and the vague, indistinct character of the ideas of natural phenomena generally, a contrast which did not disappear until the foundations of modern science began to be laid.

We should miss the most essential point of the difference between medieval and modern learning if we looked upon it as mainly a difference either in the precision or the amount of knowledge. The development of both these qualities would, under any circumstances, have been slow and gradual, but sure. We can hardly suppose that any one generation, or even any one century, would have seen the complete substitution of exact for inexact ideas. Slowness of growth is as inevitable in the case of knowledge as in that of a growing organism. The most essential point of difference is one of those seemingly slight ones, the importance of which we are too apt to overlook. It was like the drop of blood in the wrong place, which some one has told us makes all the difference between a philosopher and a maniac. It was the difference between a live tree and a dead one; between an inert mass and a growing organism. The transition of knowledge from the dead to the living form must, in any complete review of the subject, be looked upon as the really great event of modern times. Before this event the intellect was bound down by a scholasticism which regarded knowledge as a rounded whole, the parts of which were written in books and carried in the minds of men. The student was taught from the beginning of his work to look upon authority as the foundation of his beliefs. The older the authority, the greater the weight it carried. So effective was this teaching that it seemed never to have occurred to individual men that they had every opportunity enjoyed by Aristotle of discovering truth, with the added advantages of all his knowledge to begin with. With all the development of formal logic, that practical logic which could see that the last of a series of authorities, every one of which rested on those which preceded it, could never form a surer foundation for any doctrine than that supplied by its original propounder. The result of this view of knowledge was that, although during the fifteen centuries following the death of the geometer of Syracuse, great universities were founded at which generations of professors expounded at the learning of their time, neither professor nor student ever suspected

what latent possibilities of good were concealed in the most familiar operations of nature. Every one felt the wind blow, saw water boil and heard the thunder crash, but never thought of investigating the forces here at play. Up to the middle of the fifteenth century the most acute observer could scarcely have seen the dawn of a new era.

In view of this state of things it must be regarded as one of the most remarkable facts in evolutionary history that four or five men, whose mental constitution was either typical of the new order of things or who were powerful agents in bringing it about, were all born during the fifteenth century—four of them at least at so nearly the same time as to be contemporaries.

Leonardo da Vinci, whose artistic genius has charmed succeeding generations, was also the first practical engineer of his time, and the first man after Archimedes to make a substantial advance in developing the laws of motion. That the world was not prepared to make use of his scientific discoveries does not detract from the significance which must attach to the period of his birth.

Shortly after him was born the great navigator whose bold spirit was to make known a new world, thus giving to commercial enterprise that impetus which was so powerful an agent in bringing about a revolution in the thoughts of men.

The birth of Leonardo was shortly followed by that of Copernicus, the first after Aristarchus to demonstrate the true system of the world. In him more than in any of his contemporaries do we see the struggle between the old modes of thought and the new. It seems also pathetic and is certainly most suggestive of the general view of knowledge taken at this time that, instead of claiming credit for bringing to light great truths before unknown, he made a labored attempt to show that, after all, there was nothing really new in his system, which he claimed to date from Pythagoras and Philolaus. In this connection it is curious that he makes no mention of Aristarchus, who, I think, will be regarded by conservative historians as his only demonstrated predecessor. To the hold of the older ideas upon his mind we must attribute the fact that in constructing his system he took great pains to make as little change as possible in ancient conceptions.

Luther, the greatest thought-stirrer of them all, practically of the same generation with Copernicus, Leonardo, and Columbus, does not come in as a scientific investigator, but as the great loosener of chains which had so fettered the intellects of men that they dared not think otherwise than as the authorities had thought. Later in the same century was born Paracelsus, in whose checkered life we see, as in the case of Copernicus, the struggle between the old modes of thought and the new.

Almost coeval with the advent of those intellects was the discovery of the art of printing with movable type. Gutenberg was born during the first decade of the century, and his associates and others credited with the invention not many years afterward. If we accept the principle on which I am basing my argument, that we should assign the first place to the birth of Paracelsus, the struggle between the old modes of thought and the new.

Let us not forget that, in assigning the actors then born to their places, we are not recounting history, but studying a special phase of evolution. It matters not for us that no university invited Leonardo to its halls, and that his science was valued by his contemporaries only as an adjunct to the art of engineering. The great fact still is that he was the first of mankind to propound laws of motion. It is not for anything in Luther's doctrines that he finds a place in our scheme. No matter for us whether they were true or false. What he did toward the evolution of the scientific investigator was to show by his example that man might question the best established and most venerable authority and still live—still preserve his intellectual integrity—still command a hearing from nations and their rulers. It matters not for us whether Columbus ever knew that he had discovered a new continent. His work was to teach that neither hydra, chimera, nor abyss—neither divine injunction nor infernal machination—was in the way of men visiting every part of the globe, and that the problem of conquering the world reduced itself to one of sails and rigging, hull and compass. The better part of Copernicus was to direct man to a viewpoint whence he should see that the heavens were of like matter with the earth. All this done, the acorn was planted from which the oak of our civilization should spring. The mad quest for gold which followed the discovery of Columbus—the questionings which absorbed the attention of the learned—the indignation excited by the seeming vagaries of a Paracelsus—the fear and trembling lest the strange doctrine of Copernicus should undermine the faith of centuries—were all helps to the germination of the seed—stimuli to thought which urged it on to explore the new fields opened up to its occupation. This given, all that has since followed came out in the regular order of development, and need be here considered only in those phases having a special relation to the purpose of the present assembly.

So slow was the growth at first that the sixteenth century may scarcely have recognized the inauguration of a new era. Torricelli and Benedetti were of the third generation after Leonardo; and Galileo, the first to make a substantial advance upon his theory,

was born more than a century after him. Only two or three men appeared in a generation who, working alone, could make real progress in discovery, and even these could do little in leavening the minds of their fellowmen with the new ideas. Up to the middle of the seventeenth century an agent which all our experience since that time shows to be necessary to the most productive intellectual activity was wanting. This was the attrition of like minds, making suggestions to each other, criticising, comparing, and reasoning. This element was introduced by the organization of the Royal Society of London and the Academy of Sciences of Paris. The members of these two bodies seem like ingenious youths suddenly thrown into a new world of interesting objects, the purposes and relations of which they had to discover for themselves. The novelty of the situation is strikingly shown in the questions which occupied the minds of the incipient investigators. One natural result of British maritime supremacy was that the aspirations of the fellows of the Royal Society were not confined to any continent or hemisphere. Inquiries were sent all the way to Batavia to know "whether there be a hill in Sumatra which burneth continually, and a fountain which runneth pure balsam." The astronomical precision with which it seemed possible that physiological operations might go on was evinced by the inquiry whether the Indians can so prepare that stupefying herb datura that "they make it lie several days, months, years, according as they will, in a man's body without doing him any harm, and at the end kill him without missing an hour's time." Of this continent one of the inquiries was whether there be a tree in Mexico that yields water, wine, vinegar, milk, honey, wax, thread, and needles.

Among the problems before the Paris Academy of Sciences those of physiology and biology took a prominent place. The distillation of compounds had long been practised, and the fact that the more spirituous elements of certain substances were thus separated naturally led to the question whether the essential essences of life might not be discoverable in the same way. In order that all might participate in the experiments, they were conducted in the full session of the academy, thus guarding against the danger of any one member obtaining for his exclusive personal use a possible elixir of life. Cats, dogs, birds of various species, a wide range of the animal and vegetable kingdom, in fact, were thus analyzed. The practice of dissection was introduced on a large scale. That of the cadaver of an elephant occupied several sessions, and was of such interest that the monarch himself was a spectator.

To the same epoch with the formation and first work of these two bodies belongs the invention of a mathematical method which in its importance to the advance of exact science may be classed with the invention of the alphabet in its relation to the progress of society at large. The use of algebraic symbols to represent quantities had its origin before the commencement of the new era, and gradually grew into a highly developed form during the first two centuries of that era. But this method could represent quantities only as fixed. It is true that the elasticity inherent in the use of such symbols permitted of their being applied to any and every quantity; yet, in any one application, the quantity was considered as fixed and definite. But most of the magnitudes of nature are in a state of continual variation; indeed, since all motion is variation, the latter is a universal characteristic of all phenomena. No serious advance could be made in the application of the algebraic method to the expression of physical phenomena until the language of that method could be so extended as to express variation in quantities, as well as the quantities themselves. This extension, worked out independently by Newton and Leibnitz, must be classed among the greatest epoch-making conceptions in exact science. With it the way was opened for the unimpeded and continually accelerated progress of the last two centuries. The feature of this period which has the closest relation to the purpose of our coming together is the seemingly unending subdivision of knowledge into specialties, many of which are becoming so minute and so isolated that they seem to have no interest to any but their few pursuers. Happily science itself has afforded a corrective for its own tendency in this direction. The careful thinker will see that in these seemingly diverging branches common elements and common principles are coming more and more to light. There is an increasing recognition of methods of research and of deduction which are common to large branches or to the whole of science. We are more and more recognizing the principle that progress in knowledge implies its reduction to a more exact form, and the expression of its ideas in language more or less mathematical. The problem before the organizers of this congress was, therefore, to bring the sciences together, and seek for the unity which we believe underlies their infinite diversity. The assembling of such a body as now fills this hall was scarcely possible in any preceding generation, and is made possible now only through the agency of science itself. It differs from all preceding international meetings by the universality of its scope, which aims to include the whole of knowledge. It is also unique in that none but leaders have been sought out as members. It is unique in that so many lands have delegated their choicest intellects to carry on its work. They come from the country to which our republic is indebted for a third of its territory, including the ground on which we stand; from the land

which has taught us that the most scholarly devotion to the languages and learning of the cloistered past is compatible with leadership in the practical application of modern science to the arts of life; from the island whose language and literature have found a new field and a vigorous growth in this region; from the last seat of the Holy Roman Empire; from the country which, boasting of the only monarch that ever made an astronomical observation at the Greenwich Observatory, has enthroned science in one of the highest places in its government; from the peninsula so learned that we have invited one of its scholars to come here and teach us our own language; from the land which gave birth to Leonardo, Galileo, Torricelli, Columbus, Volta—what an array of immortal names!—from the little republic of glorious history which, breeding men rugged as its eternal snow-peaks, has yet been the seat of scientific investigation since the day of the Bernoullis; from the land whose heroic dwellers did not hesitate to use the ocean itself to protect it against invaders, and which now makes us marvel at the amount of erudition compressed within its little area; from the nation of the farthest East, which, by half a century of unequalled progress in the arts of life, has made an important contribution to evolutionary science through demonstrating the falsity of the theory that the most ancient races are doomed to be left in the rear of the advancing age—in a word, from every great center of intellectual activity on the globe I see before me eminent representatives of that world-wide which we have come to celebrate.

Gentlemen and scholars all! You do not visit our

votaries, the projectors, organizers, and supporters of this Congress of Arts and Science will be justified of their labors.

SIMON NEWCOMB.

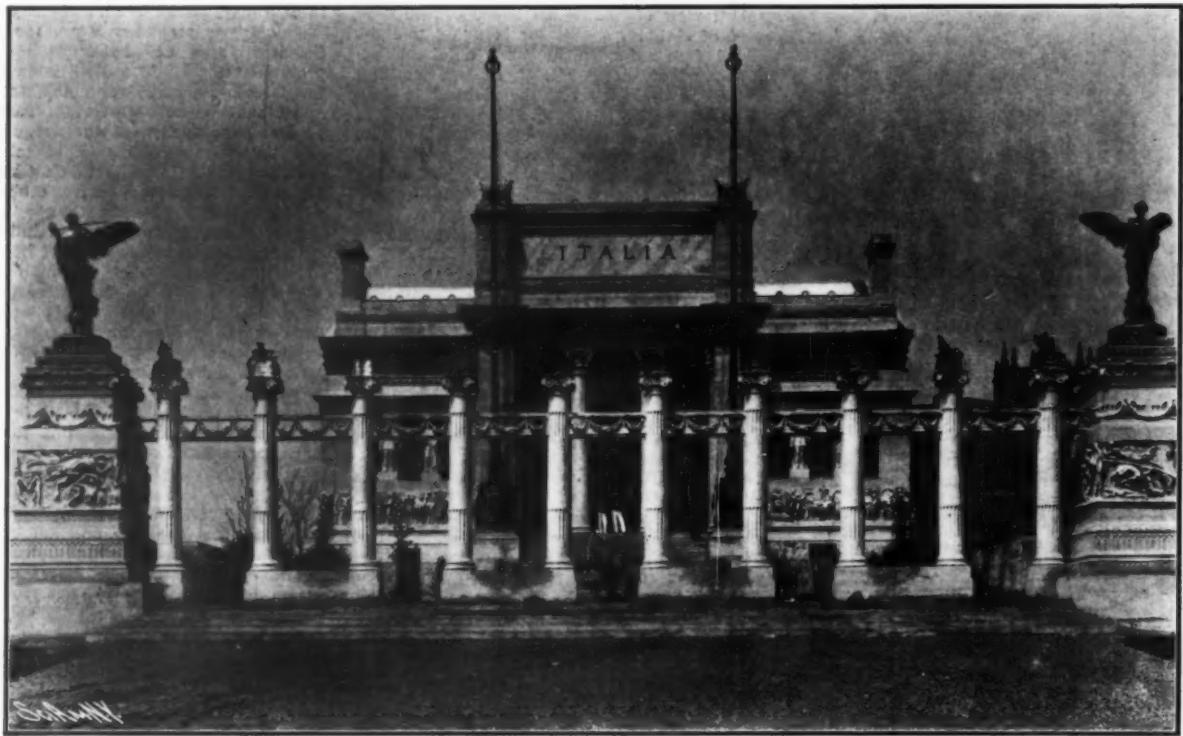
THE ITALIAN PAVILION AND EXHIBIT AT THE WORLD'S FAIR.

By the St. Louis Correspondent of the SCIENTIFIC AMERICAN.

THE Royal Italian Pavilion at the St. Louis Fair is one of the most handsome of the foreign pavilions, and forms a worthy member of the group of such buildings that adjoins the World's Fair Administration Building. It is designed in the style of the ancient villas of the Emperors of the Caesarean age, with their gardens and fountains. At each end of the handsome front colonnade is a sculptured base, crowned by a "Victory" of gilded bronze. The bas-reliefs which decorate the bases are wrought in imitations of the ancient style. On one of them is a figure representative of wireless telegraphy, and on the other a figure typical of young and powerful America. After ascending the first stairs and passing through the first colonnade, which is enriched with marble and porcelain work, one enters the garden, modeled after those in which the Romans used to spend their leisure. The building itself is erected on a strong base more than fifteen feet in height, and is approached by a flight of stairs forty-five feet in width. The front is formed by a central body in the Corinthian style, flanked by two portions of less height ornamented with marble and bronze work. The caryatides of the three latticed windows are authentic copies

make his choice according to his own ideas on the subject. There are scores of groups that were modelled, not to show the graceful human form nor the lovely human face, but rather the texture of a half bathing suit or a lace and embroidered bonnet. They are babies seated on pillows, marble pillows that are so faithfully portrayed that one can scarcely resist the temptation to press them, so plastic and soft do they appear.

Scattered among the pure white marbles and those of variegated color are many pieces that at first glance look like old ivory. On second thought, one remembers that they are stained in imitation of the marble that lay buried for centuries, and were softened in tone by long contact with the soil. The marble, after it is stained, is polished so that it has all the effect of the low age. These old marble figures are modern copies, while the copies of the old masters, the originals of which are yellow with age, are all done in pure white. With the bronzes in the collection this rule has not been carried out. The original bronze figures and groups are in the natural color of bronze, while the copies of the famous Naples collection have the exquisite green and purple tones of the original. The scarred surface and the myriad colors that were produced by the hot ashes from Vesuvius have been imitated faithfully by the tools and by heat, so that these copies present almost exactly the appearance of those that were buried in the ruins of Pompeii. In this collection of statuary is one painting, the property of Prof. Petrilli, that has all the internal evidence of being from the brush of that famous old master, Fa-



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THE ITALIAN PAVILION AT THE ST. LOUIS EXPOSITION.

shores to find great collections in which long centuries of humanity have given expression on canvas and in marble to their hopes, fears, and aspirations. Nor do you expect institutions and buildings hoary with age. But as you feel the vigor latent in the fresh air of these expansive prairies, which has collected the products of human genius by which we are here surrounded and, I may add, brought us together—as you study the institutions which we have founded for the benefit not only of our own people but of humanity at large—as you meet the men who, in the short space of one century, have transformed this valley from a savage wilderness into what it is to-day—then may you find compensation for the want of a past like yours by seeing with prophetic eye a future world power of which this region shall be the seat. If such is to be the outcome of the institutions which we are now building up, then may your present visit be a blessing both to your posterity and ours, by making that power one for good to all mankind. Your deliberation will help to demonstrate to us and to the world at large that the reign of law must supplant that of brute force in the relations of the nations, just as it has supplanted it in the relations of individuals. You will help to show that the war which science is now waging against the sources of disease, pain, and misery offers an even nobler field for the exercise of heroic qualities than can that of battle. We hope that when, after your all too fleeting sojourn in our midst, you return to your own shores, you will long feel the influence of the new air you have breathed in an infusion of increased vigor in pursuing your varied labors. And if a new impetus is thus given to the great intellectual movement of the past century, resulting not only in promoting the unification of knowledge, but in widening its field through new combinations of effort on the part of its

of the ancient caryatides of Greek origin, now in the castle of Albano. Besides the sculpture and bronze vases, the front is embellished by two lofty poles upon bronze bases. The bas-reliefs in imitation of ancient marble, which surround the building, represent the last searches for the North Pole, and various discoveries in science, navigation, and the arts. After passing through the vestibule and crossing the central floor, one enters the principal hall, which is flanked by two smaller halls. The decoration of the main hall is rich, and characteristic of classic times. It contains among many other objects of art a faithful copy of the famous Etruscan vase, now in the gallery of Florence, and also a good copy in marble of the Roman group of wrestlers. In the recesses of the west hall are oil paintings of the King and Queen of Italy.

Outside of the very beautiful government pavilion, the finest element of the Italian display of the World's Fair is unquestionably the vast collection of Italian sculpture, that occupies the northwest corner of the Palace of Manufactures. So numerous and highly meritorious is this display, that as one comes suddenly upon it, he instinctively feels that he must have wandered by mistake into the Fine Arts Building. The collection of statuary is the property of half a dozen Florentine firms. It consists of copies in marble and bronze of the old masterpieces of sculpture, besides original figures and groups in Castellina, Carrara, and colored marbles, the work of a dozen or more of the modern Italian sculptors. The transition from the work of the Greek sculptor to that of the Italian could not be shown more strikingly than in this collection. Here may be seen, side by side, the Venus of Milo and the modern conception of Venus of the year 1904. The ancient marbles were art creations, pure and simple, while the marbles of the modern Italian sculptors are realistic to the highest degree, and the visitor can

Lippo Lippi. The entire collection is valued at a million dollars.

THE NATURE OF SOLID BODIES.

In a communication to the Faraday Society, which has been published in a recent issue of the Philosophical Magazine, Mr. G. T. Beilby deals further with the theories of the nature of solids to which he has led by his study on the real nature of polished surfaces. All solids he contends may be classed either as crystalline or amorphous bodies, or as a mixture of these. If a body is allowed to cool slowly from the molten state, it crystallizes, the molecules arranging themselves in regular order; but for this to take place time is necessary. If suddenly quenched, the orientation of the molecules cannot occur, and the resulting solid is, he states, a sort of instantaneous photograph of the molecules in their liquid condition. The crystalline state is, however, the more stable of the two conditions of solid matter and the amorphous may be caused to pass into the crystalline state by simply raising the temperature, even if the melting point is not approached. The contrary change of crystalline matter back into amorphous cannot be effected by mere alterations of temperature, but is easily brought about by performing mechanical work on the metal. In this passage from the "C," or annealed condition, as he calls it, to the "A," or hardened condition, a substance passes through an intermediate stage where it has all the properties of a viscous fluid. In the act of polishing a metal the surface is rendered fluid by the polishing agent, and flows into and fills up the pits and hollows characteristic of the crystalline structure of the annealed body. The "flowed" portion remains in the hardened or "A" state, which is found to be more easily acted on by chemicals than

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the same material in the "C" condition. Hence, if the polished surface is etched, the whole of the "flowed" material can be dissolved off, and the original pitted and mottled surface will reappear. Even brittle bodies like antimony and bismuth show this phenomenon of flowing very well.

In the case of silver it is possible by rolling, hammering, and wire-drawing to change such a proportion of the soft crystalline metal into the amorphous condition that the tensile strength is raised from under 10 to over 20 tons per square inch, while silver foil may be rendered so hard and springy by hammering that it can be used as the reed of a wind instrument. Heating this reed to but 260 deg. C., however, is sufficient to entirely change it back into its original crystalline state, when it is so soft that it can be molded by the mere pressure of the fingers. Under the microscope annealed silver always appears crystalline, the constituent grains being built up of similarly oriented lamellae. Hardened silver, on the other hand, appears vitreous at the surface, all edges and angles being rounded just as if the surface was a viscous liquid. If etched, the layers immediately below the surface appear finely granular; while if the etching is carried still deeper, the original crystals can be detected in a more or less broken-up condition. Films of silver deposited on glass by chemical means are opaque, but if heated to 250 deg. or 300 deg. C. they become transparent; the opacity may be restored by burnishing them.

The effects of rolling, pressing, or wire-drawing are similar in their nature to those of polishing, but the effect extends more deeply into the metal. Wherever the strain in the interior of the metal subjected to these processes exceeds a certain amount the constituent particles slide over each other, and the "liquid" transition state is formed at the interfaces of slip, which solidifies into a cage or network of the hardened amorphous material, inclosing the original crystalline grains. Thus in the slip surfaces detected in overstrained metals by Prof. Ewing and Mr. Rosenhain, the metal surfaces on the two sides of the slip enter into the mobile stage, and immediately set, as stated, into the hard amorphous state. Slipping is easy so long as fresh moving surfaces are forthcoming to supply the mobile transition metal; but after a certain time the rigidity of the hard amorphous network formed is so great that no further slipping occurs unless the intensity of stress is increased, and the metal as a whole is thus rendered more rigid, harder, and stronger. In wire-drawing this conversion of the soft crystalline metal into the hard amorphous state proceeds so far that Swedish iron having a tensile strength of 20 tons per square inch in the bar makes wire having a strength of 80 tons per square inch. Even so, the whole of the metal is far from having been all converted into the amorphous condition, and repeated attempts have shown it impossible to reach this result even in thin gold and silver films. Hence in practice it is also impossible to reach the tensile strength which would be attained were the metal wholly converted into the "A" condition.

TRAGACANTH.

THE Pharmaceutical Journal says that four principal qualities of tragacanth are offered for sale in the Kermanshah (Persia) markets. The first quality is received from Burujird, Nehavend, and Kermanshah, and fetches, unsorted, from 28 to 32 krans (52 krans = £1) per maund tabrizi. It is sorted into three classes, which fetch about 35 to 36, 30 to 31, and 28 to 29 krans respectively. The second quality is received from Kurdistan, Kermanshah, Nehavend, and Burujird, and fetches, unsorted, from 11 to 18 krans per maund. It is sorted into five classes, fetching 22, 18, 14, 12, and 8 krans per maund respectively. The third quality ("zardeh" in Arabic) is known in Persia under the name of "arrehbor" (cut with a saw), as the gum exudes from the branches which have been cut with a saw. Arrehbor costs 8 to 11 krans per maund. When sorted, the different classes fetch 12, 9, 8, and 6 krans per maund respectively. It is obtained from Mount-Dalahu, Pusht-i-Kuh, Khorremabad, and Burujird. The fourth quality, or strong gum, which is known under the name of kurreh (kora) is obtained from Mount-Dalahu, Pusht-i-Kuh, Khorremabad, and Burujird. First quality katyra is obtained from the plant known as "gavan-sefid," or white gavan, by incisions, from which the gum exudes. Second quality is obtained from the yellow gavan, which is a larger plant than the gavan-sefid. The top of the plant is burnt, and when the leaves are all consumed the fire is put out and incisions are made. The following morning the gum which has oozed out of the incisions is gathered. This operation is repeated three or four times, the quality improving each time. The arrehbor gum exudes from the branch of a small tree, the top of which has been burnt and the branches then cut with a saw. The branches are cut three or four times. The plant yielding kora is treated in the same way as that yielding arrehbor gum. The operation is repeated three times, and the quality of the gum deteriorates each time. After seven years' constant tapping the gavan plants dry up. In Bagdad, gum is not usually sold sorted, and, therefore, prices for each separate quality cannot be obtained. On account of disturbances in Luristan there was this year a very limited supply of gum tragacanth. The total amount put on the Kermanshah market is said to be only one-third of the amount usually disposed of every year. There was a rise of fully 10 per cent in the price of gum tragacanth as compared with last

year's prices. The indiscriminate tapping of the plant giving katyra will soon cause the supply of gums to diminish. Already the fields in the vicinity of Kermanshah are almost completely exhausted.

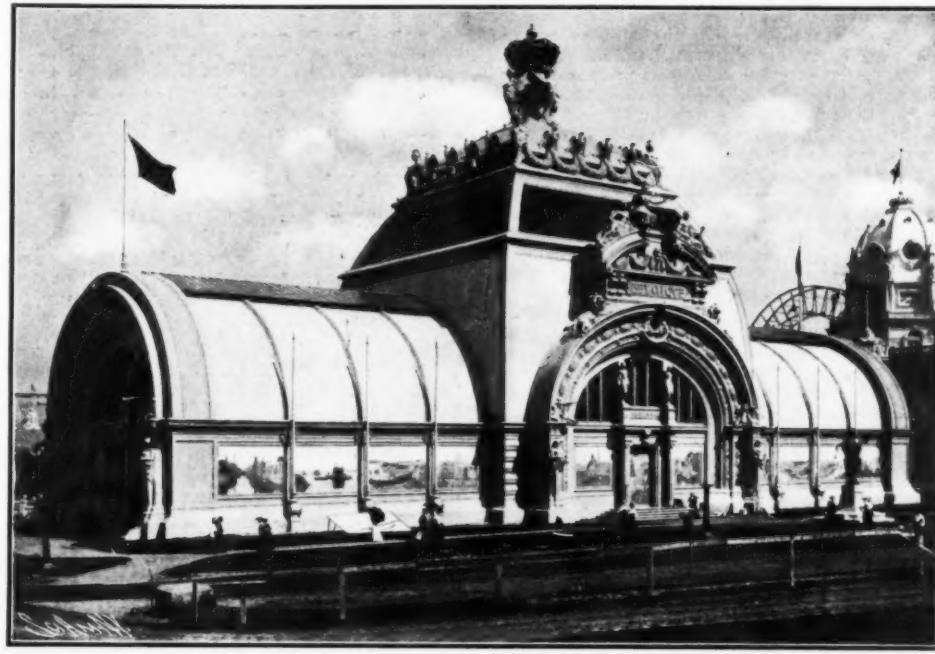
THE BELGIAN PAVILION AND EXHIBIT AT THE WORLD'S FAIR.

By the St. Louis Correspondent of the SCIENTIFIC AMERICAN.

THE Belgian building at the World's Fair is one of the most imposing structures on the foreign reservation. It is located directly in front of the Administra-

provinces of the kingdom. Brussels, Antwerp, Ghent, Bruges, Liege, and other cities, renowned in commerce or for their historical importance, are thus represented.

Like the German Emperor, the King of Belgium has taken great personal interest in the national exhibit. The interior of the building is divided into exhibition rooms, by partitions extending to about the height of the springing of the roof, whose interiors are entirely filled by a carefully-selected and highly illustrative display. Particular attention has been given to the school and university systems of Belgium, which are illustrated by an elaborate display of photographs and



THE BELGIAN GOVERNMENT BUILDING.

tion Building, where it occupies a tract 310 x 200 feet. It has the distinction of being one of the few steel-built structures on the ground, the framework consisting of steel trusses, which are of general semi-circular section, and extend across the entire 62-feet width of the building. The steel framework is sheathed with wood and finished in ornamental staff. The steel trusses were made in Belgium, as were also the staff models, and after the exposition is over the trusses will be returned to Belgium, where the building is to be re-erected for use at the Exposition at Liege, in 1905. The general plan of the building is that of a cross with a massive dome at the intersection. There are four entrances, one at each end of the main aisle and one at the entrance to each transept. A feature peculiar to this building, and one which gives it a most charming effect which can only be partly appreciated from our engraving, is that the exterior walls of the building, below the springing of the roof, are painted in a series of panels, illustrating the leading cities and

drawings. The exhibit includes illustrations of the university and school buildings, of the renowned technical schools, and of the agricultural colleges. There is a complete exhibit of the various text books used, and samples of the work of the students are shown. The products of the skill of the technical scholars are noticeable for their careful workmanship and high finish, and the graduates of the schools are so thoroughly instructed, that they are always able to obtain employment at the close of the college course. Under the main dome are seen some lovely ivory statuettes and some bronze statuary of exceedingly high merit. The largest individual displays are those of four completely furnished rooms. One of these is a private sitting room designed and furnished on the principles of the New Art, of which Germany makes such a very elaborate display in the Varied Industries Building. Adjoining that is a room furnished after the prevailing style of the wealthier Belgian families, in which it can be seen that there is a preference for dark coloring and massive



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FLEMISH DINING ROOM IN THE BELGIAN BUILDING.

and richly gilded furniture. Another room known as the Royal Room contains a lifelike bust of the King, and its general furnishing is modeled after one of the interiors in the royal palace. The fourth room, and decidedly the most pleasing of the four, is a very charming Flemish dining room of which we present an illustration.

To American railroad travelers, the exhibit of a single compartment of a sleeping car on the Belgian railway will be of considerable interest. The car of which it would form a part is of the side corridor type, and the compartment is complete, with its separate lavatory, folding bed, writing desk, etc. An exhibit that attracts considerable attention is one intended to show the development of the railway from the earliest times to the present year. This is done by small models of railway cars and locomotives, the models being made to scale with great fidelity as to detail. A particularly fine exhibit is one showing the manufacture of rifle and shot-gun barrels, the method of forging the same being shown in different stages, which illustrate the extraordinary amount of work that is put into the barrel to give it the required qualities of high elastic strength and toughness. The industrial development of Belgium is a story well worth the study of the political economist, and one whole room in the building is given up to the illustration of this development by means of statistics of industry and commerce. In another room is the exhibit of native wine, conserves, sauces, and kindred products. In another, known as the flax and linen room, are exhibits showing the industry from the raw material to the finished fabrics. Mention should be made of a tree, six feet in height, which has been forged out of a single piece of iron, as an evidence of what can be done with the blacksmith's forge and anvil and a hammer.

THE EDUCATION OF BLIND DEAF MUTES, WITH THE CASE OF HELEN KELLER.

By CHARLES RAY.

WRITING in 1809, Dr. Watson, an eminent British authority on the education of the blind, said: "Whether any instance has ever occurred of a case so melancholy as that of one of our species being born deaf and blind I am unable to say. I would gladly hope that the case has been of rare occurrence. May it ever continue so; for should it unhappily occur, what could be done for the subject of it but supply corporal sustenance? I am aware that the Abbé de l'Épée, always ingenuous and humane, had offered to undertake the instruction of such children of deprivation, upon the supposition that the touch might be employed as a medium of mental communication. But I must acknowledge I can form no notion of the practicability of this to any extent that might be termed rational without admitting the exploded hypothesis of innate ideas. Every friend of humanity will rejoice that, though we are informed the good Abbé made his offer known through the public journals of the time, it does not appear that he ever had an opportunity of reducing his theory to practice." That was penned less than a century ago; but what would the doctor have said could he have foreseen the giant strides that would be made within a comparatively short time in the education of persons suffering from this double affliction? Much has been written as to whether the blind or the deaf may be considered the least unfortunate, and the question is usually decided in favor of the blind; but the case of Miss Helen Keller has proved that even when both deprivations meet in the same individual there need be no limit to the mental development of the afflicted. This young American lady was born at Tuscumbia, Alabama, on June 27, 1880, and for a brief period possessed all the faculties of the average child. But at the age of nineteen months she suffered a serious illness, with the result that both sight and hearing departed forever. Her case, indeed, seemed hopeless; and it is not surprising that a child possessing the mental vigor which after events have proved that Helen Keller had, should have fretted and fought for release from her prison house, and have found vent for her feelings in violent fits of passion. "Once," she says, "I knew the depth where no hope was, and darkness lay on the face of all things. Then love came and set my soul free. Once I knew only darkness and stillness. Now I know hope and joy. Once I fretted and beat myself against the wall that shut me in. Now I rejoice in the consciousness that I can act, and attain heaven. My life was without past or future; death, the pessimist would say, 'consummation devoutly to be wished.' But a little word from the fingers of another fell into my hand that clutched at emptiness, and my heart leaped to the rapture of living. Night fled before the day of thought, and love and joy and hope came up in a passion of obedience to knowledge. Can anyone who has escaped such captivity, who has felt the thrill and glory of freedom, be a pessimist?"

The story of how the little blind deaf mute was taught and her mind developed until she could hold her own, as she undoubtedly can at the present time, with the most brilliant students of Girton and Newnham is a marvelous story, and not the least remarkable fact about it is that it has been told in a book written by Helen Keller herself.

When she was nearly seven years old, a teacher from the well-known Perkins Institution at Boston, Miss Sullivan, was engaged to commence her education, and if the blind girl is to be admired and congratulated for her determination and perseverance, certainly Miss Sullivan is worthy of equal praise for the patience and ingenuity which she has shown. The senses of smell and taste were well developed in the child, and of

course proved useful; but it was by touch that the great world of thought was opened out to her. Miss Sullivan began by spelling with her fingers into the palm of Helen Keller the word "water," while that liquid was poured over the child's other hand. "That living word," says the blind girl, "awakened my soul, gave it light, hope, joy—set it free!" Other words were associated with objects; and with infinite patience Miss Sullivan went from material objects to abstract ideas, and from promiscuous instruction to systematic study. Natural history and botany were taught in the open fields of the Sunny South, and geography became a delightful pastime for the eager young girl. "I built dams of pebbles," she writes, "made islands and lakes, and dug river beds, all for fun, and never dreamed that I was learning a lesson."

She was taught to read books in Braille type, and her progress was astonishingly rapid. In infancy, before her illness, she had indulged in baby prattle; but after the blindness and deafness came, the child was dumb save for inarticulate sounds. At ten years of age, however, she learned that a Norwegian girl, both blind and deaf, had been taught to speak, and at once Helen Keller was all eagerness to achieve a similar success. The difficult task of instructing her was undertaken by Miss Sarah Fuller, and how thoroughly well she and her pupil succeeded in what to the uninitiated must have seemed an impossibility may be gathered from the fact that Helen Keller can now talk fluently not only in English but also in German and French, and she has publicly addressed a legislative committee in the United States on behalf of the founding of trade schools for the adult blind. As is generally known, the seeing deaf mutes are taught to speak by watching the mouths of their teachers as they talk, and feeling the various muscles of the throat and face as various sounds are articulated. Helen Keller had only her touch to guide her; but in the first lesson of one hour she had learned to pronounce fairly distinctly the letters M, P, A, S, T, I. Progress was now as rapid as in the acquirement of the touch-alphabet, and after eleven lessons the girl could speak the sentence, "It is warm." Miss Sullivan took up the work of continuing this branch of teaching, and then for two years Miss Keller attended the Wright-Humason School for the Deaf in New York, where her training in lip-reading was perfected.

The girl's thirst for knowledge was insatiable, and particularly was she interested in literature. She soon knew whole passages of Tennyson and other poets, and these she could repeat vocally with real emphasis and feeling, so that often her listeners were moved to tears. After receiving a thoroughly sound groundwork of education in all subjects, Helen Keller, accompanied of course by Miss Sullivan, proceeded to the Cambridge School for Young Ladies, preparatory to entering Radcliffe College, where she determined to work for a degree. At both the school and the college Miss Sullivan sat by her pupil's side, repeating upon the girl's fingers the lessons that were given, and never once was any difficulty experienced. Of all the pupils, Miss Keller was the quickest to grasp a point, and at the examinations she passed with the highest success in Greek, Latin, French, English literature and history, mathematics, and art, receiving honors in German and English. The examinations lasted nine hours, and the blind girl received no advantages or favoritism. She had the questions read to her, and then gave her answers upon the typewriter in the specified time allowed to other pupils. Her method of studying art, in which she came to take a keen interest, was to visit the galleries, and, perched upon steps, to pass her fingers lightly over the statuary. In 1893 she was taken to the World's Fair at Chicago, and there the various treasures—jewels, bronzes, Oriental work, etc.—were placed in her fingers so that she might understand their form and nature. Even in instrumental music Helen Keller has come to take a delight, for, although she is quite deaf, so sensitive are her nerves that she appreciates the relative value of the sounds by the vibration, and has been able to understand the various styles of the leading composers.

Many prominent men have been interested in the young girl's case, and she has numbered among her friends and acquaintances Oliver Wendell Holmes, Phillips Brooks, Whittier, Dr. Everett Hale, Mark Twain, Sir Henry Irving, and William Dean Howells. At the present time she is completing her studies; but already she has a profound knowledge of men and things, of modern and classical learning; and a new book which she has written on Optimism, setting forth her philosophy of life, is even a greater proof than her autobiography of the power of her intellect and her determined energy.

Helen Keller's case is indeed a triumph of human nature, and a proof that there are no disadvantages of matter which cannot be overcome by mind. In no study, save music and the drama, is she one whit behind people who can see, and even of those things she has a very thorough grasp and appreciation. Of course, she has had the advantage of personal and individual tuition, necessitating infinite patience; but even with these it might have seemed an utter impossibility ever to break through the prison walls from within or without, as Dr. Watson, himself an authority on the subject, declared less than a century ago.

Without seeking to minimize in the slightest degree the credit for skill and patience and ingenuity due to Helen Keller's instructors, we must recognize that they owe a vast deal to Dr. Howe, a former manager of the Institution for the Blind at Boston. It was Dr. Howe who first showed the possibilities that lay before a blind deaf mute, and his training of Laura Brid-

man was perhaps a greater triumph than even Helen Keller's case, seeing that not only was there no earlier case of success for incentive and encouragement, but all precedent and opinion were dead against him. Before we give some account of how Dr. Howe enabled this afflicted girl to communicate with the outside world, it will be interesting to refer to two earlier cases of blind deaf mutes. The first known instance, though undoubtedly there must have been others unrecorded, is that of Hannah Lamb, who lived at Burleigh Street in the Strand, London. Her story, told in a few lines in the Gentleman's Magazine for November, 1808, is terribly tragic. No attempt whatever seems to have been made to enable her to communicate with others; and when nine years of age she appears to have left her bed one night to sit by the fireside while her mother was out of the room, and a red-hot cinder, falling from the grate, set fire to her clothes. She was terribly burned, and four hours later died from her injuries. The next case we find is that of James Mitchell, the son of the Rev. James Mitchell, of Ardclach, Inverness. He came before the notice of Sir Astley Cooper, the distinguished surgeon, in 1808, when his father brought him to London to see if his eyes could be operated upon. The lad was then thirteen years of age, and although to all intents and purposes blind, he was able to distinguish a strong light. This was ascertained from the fact that he used to retire to an outhouse or room, and closing the doors and shutters, would place his eye at any small opening to get the full benefit of the sun's rays. Sir Astley Cooper pierced the tympanum of each ear, but without result, and two years later the right eye was operated upon, with indications that further use of the needle might have resulted in the eyes being rendered comparatively useful. But unfortunately the boy's father died at this period, and the lad returned to Scotland without undergoing any further operation.

Mitchell's sense of smell was very acute, and if a stranger entered, however quietly, the room where he was sitting, James could detect the visitor's presence, and locate him quickly by the scent. He would then examine the stranger, and get an impression from the sense of touch. The boy appears to have obtained considerable pleasure from the vibration caused by striking his teeth with metal, and he would often sit for hours with a bunch of keys, testing each key in succession, and evidently delighting in the varied vibrations. No serious attempt to communicate with him or to enable him to communicate with others seems to have been made, although his mother and sister developed a very rude and elementary method of indicating to him by touch and action what they wished him to know. Thus, to signify approbation the boy's head or back was patted gently, and if this were withheld he seems to have known that his friends were displeased. Once when his mother went away from home for a time, his sister was able to tell him how long the parent would be absent by placing his head upon a pillow once for each night she would be away. There being no method of communicating freely with him, it was of course impossible ever to teach him religious truths; but he accompanied the family to church, and was habitually present at family prayers and behaved reverently, kneeling when the others knelt. Shortly after his father's death a minister happened to be staying in the house, and on Sunday evening James pointed to his father's Bible, and signified by his action that the family should kneel. Exactly how much may be inferred from this it is impossible to say; but there seems no reason to suppose that James had any notion of the existence of beings superior to himself.

The case of Laura Bridgeman is remarkable in more ways than one; for not only was she the first blind deaf mute to have a means of communication with the outer world opened to her, but she was a most unpromising subject with which to commence such an experiment. Laura Bridgeman was a weakly infant from the first; but just before she was two years of age she had a serious illness that prostrated her, and resulted in the complete destruction of the organs of sight and hearing. When at last, after two years of illness and convalescence, she was so far restored as to be able to sit up all day, it was discovered with dismay that not only sight and hearing were gone for ever, but that her sense of smell was also destroyed and her taste much blunted. The poor child was thus left with only one sense—that of touch—possibly a unique case in the history of humanity. He must have been a bold man who saw possibilities in a creature so handicapped. "What a situation was hers!" wrote Dr. Howe. "The darkness and silence of the tomb were around her; no mother's smile called forth her answering smile; no father's voice taught her to imitate his sounds. Brothers and sisters were but forms of matter which resisted her touch, but which differed not from the furniture, save in warmth and in the power of locomotion, and not even in these respects from the dog and the cat." Charles Dickens, who in his "American Notes" has made her early history familiar, has graphically described her as "built up, as it were, in a marble cell, impervious to any ray of light or particle of sound; with her poor white hand peeping through a chink in the wall beckoning to some good man for help, that an immortal soul might be awakened." Those who are desirous of learning how her education was commenced can read the story in "American Notes." Instead of continuing and developing the language of signs which Laura had commenced for herself, Dr. Howe determined to attempt to impart to her a knowledge of the alphabetic language in general use. Common objects such as knives, forks, keys, etc., were taken, and upon them were pasted labels with

their names, detached, and select the thing object. were separated names of the began to which was in parrot; it link of unity the moment spread great obstacles nothing but straightfor training other blind hands and rapidly seen to sleep thoughts murmur sense of stretching passed her able to rec held up her keen sense that the turned her

parting idea from the case placed

"At eleven read to her not remember it; but she this true it a lie?" not wrong. Wrong, and remembered wished to she turned her

"When I was very young one my heart beat crazy person asked her said, 'Lure' was once a persons contemplated returned to seen crazy woman walk? History of the girl, became crazy I am crazy not be crazy not was I panted, that which the

One day teacher we girl appeared the fact that raised letter into she knew fact that in the book complained to languages, or taught

Laura E. Helen Keller average yearning for religious and to promising many of us clear education, Wind and

Lack of deaf mutes of James E. we have the sadly affliction of finger-language Howe who were, and training him which has on a level facilities.—

A Gloss German simple and dissolve arabic, 5 c

herd of wild buffalo estimated to number 600. But since this region is exceedingly difficult of access, the herd is likely to increase during the coming years.

THE SIEMENS-SCHUCKERT CONTINUOUS-CURRENT WATTMETER.

BY EMILE GUARINI.

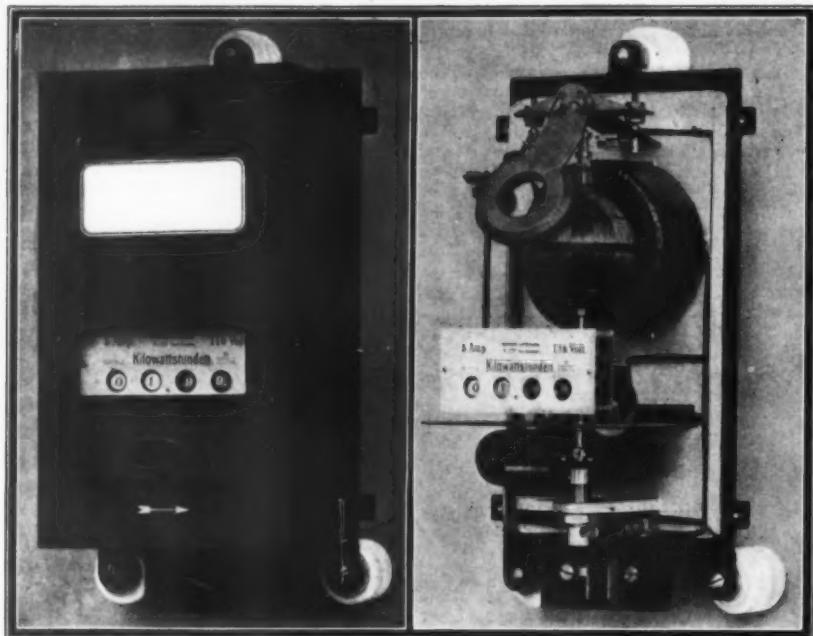
The wattmeters constructed by the Siemens-Schuckert

CONTEMPORARY ELECTRICAL SCIENCE.*

THE ETHER AND DOUBLE REFRACTION.—D. B. Brace quotes some experiments to disprove the validity of the Fitzgerald-Lorentz contraction hypothesis to explain the negative results of the Michelson-Morley experiment of interference between two rays, at right angles and parallel respectively to the earth's motion. The experiments were conducted by an extension of

A heavy beam was pivoted between the floor and ceiling so as to carry a trough with its horizontal axis intersecting the pivotal axis. This system could be rotated continuously so as to bring it into any desired position. The trough was 413 centimeters long and built of thick planking so as to give stability to the polarizing and mirror systems which it carried. Sunlight was so thrown into the trough as to keep its path the same whatever its position. The results were negative in every case. The experiments were repeated during the early part of February, 1904, when the earth's orbital velocity conspires approximately with that of the solar system in space. The conditions were quite as favorable as before, but no effect could be detected. The author concludes that the contraction hypothesis cannot explain the negative results of the interference experiments. Either the ether moves with the embedded matter, or the effect of the relative motion on the intermolecular forces and the possible consequent relative change in dimensions are very small.—D. B. Brace, Philosophical Magazine, April, 1904.

N'-RAYS.—J. Meyer has discovered some new sources of the extinguishing rays called by Blondel N'-rays, and has obtained rays of a higher penetrating power than heretofore. If a screen with patches of phosphorescent calcium sulphide is placed in the receiver of an air pump and the pump is worked, the phosphorescence decreases, being restored as soon as the pressure is restored. The same thing takes place if the screen is placed outside instead of inside the receiver. An incandescent lamp through which no current passes, or a vacuum tube, are powerful sources of N'-rays, the strain of the glass under atmospheric pressure being sufficient to account for their production. These rays are not absorbed by a slab of wood 10 centimeters thick, or a sheet of oxidized lead 1 millimeter thick and folded so as to be traversed by the rays eight times, or by a glass vessel 10 centimeters thick filled with pure water. The only bodies capable of intercepting these rays appear to be platinum 1 millimeter thick and "opal" glass 3 millimeters thick. In studying the refractive index of the rays by means of an aluminium prism, the author observed that the aluminium stored the rays in great quantity, and gave them out again for the next twenty-four hours. Ordinary and crown glass store them for a short time, and lead, copper, and pure water do



Figs. 1 and 2.—THE SIEMENS-SCHUCKERT CONTINUOUS-CURRENT WATTMETER FOR STRENGTHS OF FROM 3 TO 20 AMPERES.

Company for the measurement of continuous electric currents are characterized by the simplicity of their mechanism, the certainty of their operation, and the almost absolute accuracy of the results which they give. The apparatus belong to the motor type. The field and the armature are devoid of iron. The former, which is of coarse wire, is traversed by the current to be measured, while the armature, which is of fine wire, is connected in shunt circuit. The apparatus is therefore based upon the principle of the wattmeter, the stationary field, or inductor, being sensitive to the current and the movable armature to the voltage. The force of the motor is therefore proportional to the product of the current by the voltage, that is to say, to the watts.

In addition to the motor, the meter includes a regulator and a counting mechanism. The former consists of a copper disk mounted upon the shaft of the motor so as to revolve between the poles of a powerful magnet. It regulates the speed of the counting mechanism in such a way as to make the number of revolutions always exactly proportional to watts consumed.

The third mechanism, which serves for counting the revolutions, consists of a brass endless screw secured to the shaft of the motor and imparting motion to a helicoidal wheel, which transmits it to the dials. A pinion keyed upon the shaft of this wheel meshes with a gear wheel, upon the axis of which is placed the first dial. At every revolution, the latter raises a small weight, which, in falling, causes the other disks to advance abruptly. The disk indicates directly the consumption in kilowatt-hours. In order to completely do away with friction, the meter is provided with an auxiliary coil, which is interposed in the circuit of the armature, and is movable. The force of this is exerted permanently upon the armature and exactly balances the friction.

The advantages claimed for the instrument by the manufacturers are simplicity, the use of a single revolving axis, the absence of clockwork movements or complicated electric apparatus, ease of control, absence of variable forces, springs, etc., the possibility of following all fluctuations however abrupt and strong they may be, an almost complete insensibility to short circuits, and the possibility of operating at all times without attention.

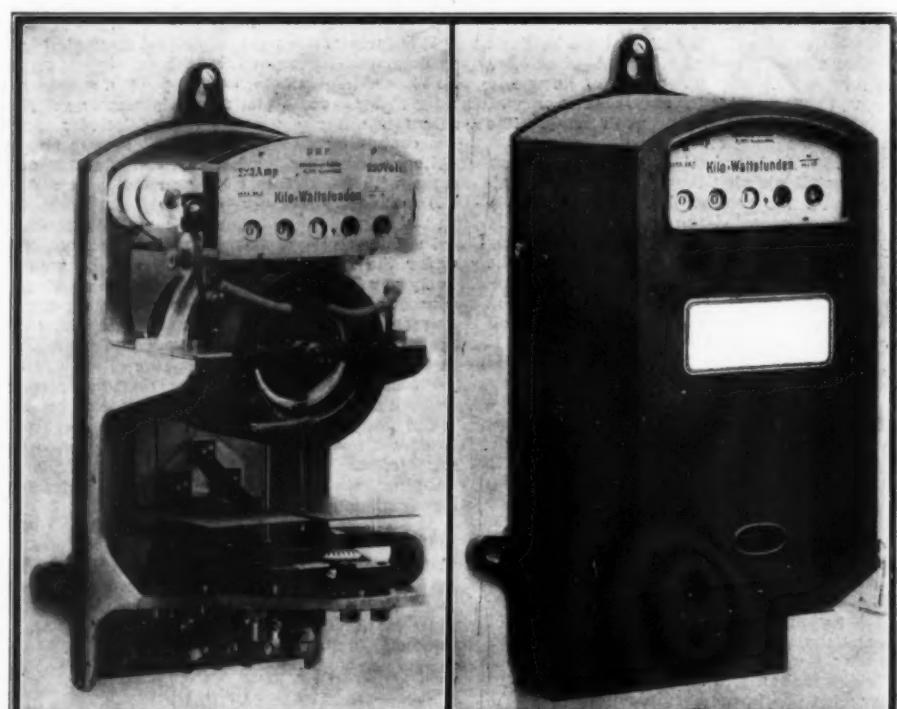
A special arrangement permits of raising the armature from its lower bearing so that this will not be damaged when the meter is being carried. The terminals are covered with a sealed box.

This meter is made in three types. The first (Figs. 1 and 2) is designed for currents of from 3 to 20 amperes; the second (Figs. 3 and 4) for currents of from 3 to 100, and the third (Figs. 5 and 6) for those of from 3 to 4,000. The maximum tension is always 600 volts. The three types are constructed either for two or three conductors.

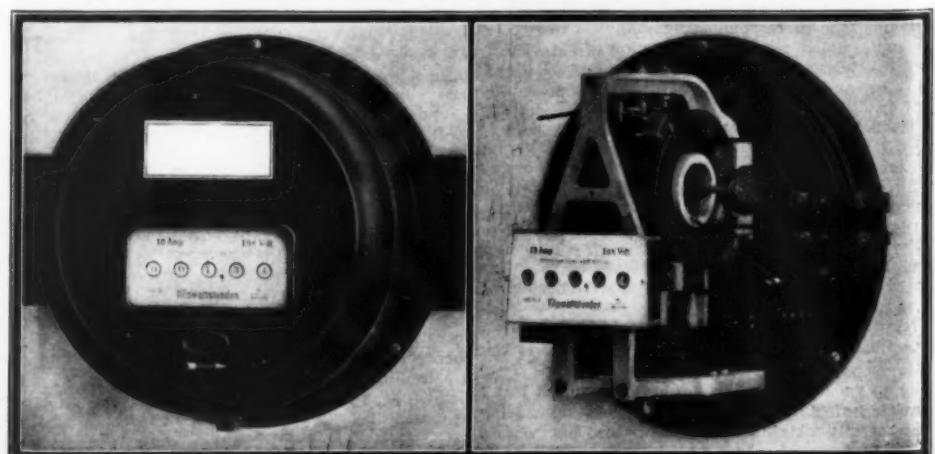
The first type is provided with a regulating magnet and with a field coil placed parallel with the back of the instrument. In the meters for three conductors, the coil is provided with two separate windings. The auxiliary coil is oblique with respect to the armature. The second type is provided with two regulating magnets and two field coils placed parallel with the back of the instrument. The arrangement is the same in the third type, save that the field coils are at right angles with the base-plate. In both types, the auxiliary coil is within the field coil.

Rayleigh's method, using a system rotating about a vertical axis, and working with either glass or water.

* Compiled by E. E. Fournier d'Albe in the Electrician.



Figs. 3 and 4.—WATTMETER FOR CURRENTS OF FROM 3 TO 100 AMPERES



Figs. 5 and 6.—METER FOR CURRENTS OF FROM 3 TO 4,000 AMPERES.

not store them at all. An aqueous solution of sodium hyposulphite remains a magazine of N-rays for a long time. The hand itself stores them for a few minutes, probably owing to the salts of the perspiration. The rays are refracted by glass, copper, and aluminium, and may be diffracted by a grating.—J. Meyer, Comptes Rendus, April 11, 1904.

PROPOSED CANAL TO CONNECT MONTREAL WITH THE HEAD OF LAKE HURON.*

By DAY ALLEN WILLEY.

In a study of the map of North America, the peculiar shape of the bodies of water known as the Great Lakes is especially noticeable. The three upper lakes—Superior, Michigan, and Huron—resemble a huge oak leaf, the last two named extending southward, while Superior stretches away to the west and north. Consequently, the vessel bound from Chicago to Buffalo must follow a course which resembles a gigantic horseshoe to reach Lake Erie, going north to the Straits of Mackinac, thence returning southward through Lake Huron and the passage connecting it with Erie. So circuitous is the route, that the idea of constructing a canal from the foot of Lake Michigan to the head of Lake Erie has been suggested, which would save no less than 375 miles. Vessels bound for the St. Lawrence River, however, must describe another curve so great that a steamer leaving the Sault Canal, which is near the 46th parallel of latitude, goes southward to near the 42d parallel, but when she reaches Montreal, she is within a few miles of the latitude of her starting point.

The majority of the vessels which enter Lake Ontario from the west are bound for ports on this body of water, very few continuing on to the St. Lawrence. This is not strange when the route available for navigation is considered. To enter Lake Ontario, the craft must pass through the locks of the Welland Canal, descending a distance of 327 feet in 26½ miles. The six artificial channels between the head of the St. Lawrence River and tide-water navigation represent 46 miles in all, with a total descent of 207½ feet distrib-

uted among the twenty-two locks. The depth of water is 14 feet in the shallower canals; consequently steamers and barges carrying over 2,000 tons of cargo cannot pass through them, and

the mouth of the Ottawa River, while its western is on Georgian Bay, one of the arms of Lake Huron. It consists of the river mentioned from its mouth to the mouth of a tributary called the Mattawa. This stream is utilized to its source in series of small lakes. The route is through these as well as Lake Nipissing, which is one of the most important sheets of water in western Ontario and the source of the French River. Lake Nipissing and its outlet form the western section of this chain of watercourses, being connected with Georgian Bay by the river named. From the data compiled by the engineers, it is found that from the bay to the St. Lawrence there is a rise of 66 feet between the mouth of the French River and Lake Nipissing. From the head of the lake to tidewater, however, there is a total descent of 630 feet. Consequently, it is necessary to form a summit level canal which will be 69 miles in length, covering the watershed between the lakes and the head waters of the Mattawa River. It is calculated that vessels bound eastward will reach the summit level by a series of three locks in the French River. On the Mattawa River the total fall of 137 feet occurs in a length of 14½ miles. Navigation on this section is to be maintained by a series of five locks, while eighteen will be required to render the Ottawa navigable from the Mattawa to the St. Lawrence. The courses of the three rivers in the chain are marked by planes of deep water of ample width to allow vessels to pass each other. Where navigation is impracticable, the obstruction consists chiefly of rapids. The Mattawa contains a series with a total descent of 55 feet in two miles, while on the French River is one of 26 feet in one mile. The rapids of the Mattawa referred to include a cataract 34 feet high. These are the greatest ascents to be avoided by artificial channels. Fortunately, the formation at the sites of the several locks and dams is such that they can be constructed on a rock foundation and of material in the vicinity. It might be added, however, that the estimated cost provides for the enlargement of the present canals of the St. Lawrence between the Ottawa and Montreal, to accommodate the largest vessels which may utilize the new route.

to Montreal is 950 miles, while the St. Lawrence seaport is 425 miles nearer Liverpool than New York.

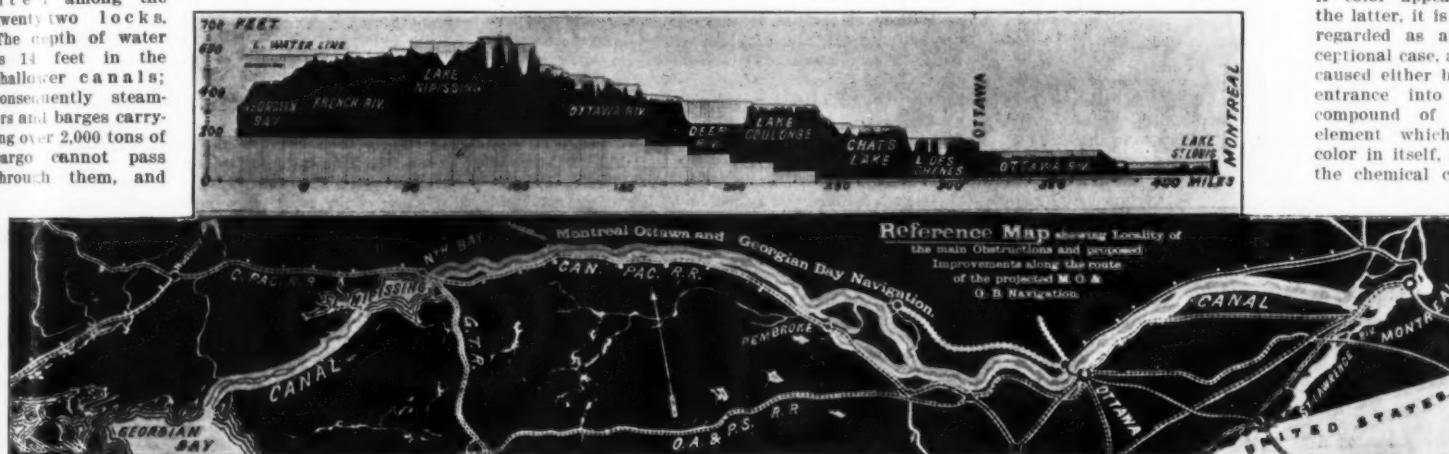
Contrasting the northern passage with that by way of Lake Ontario and the St. Lawrence River, the former is found to be 340 miles shorter. If two vessels started from Chicago to Montreal, leaving at the same time and traveling at the same rate of speed, the one going by the Georgian Bay route would be within 170 miles of Montreal when the one taking the present route reached the Welland Canal. This calculation is made after allowing for the time required to pass through both lock systems. The estimate shows that the average time for a trip to Montreal and return by way of Georgian Bay would be 19 days, including time in port. By the present route it would be 22½ days.

The development of the upper lake cities is one of the most interesting features in connection with the completion of this waterway. That the trade between Chicago, for example, and the Dominion would be enormously increased is beyond question, since such a large area of the Maritime Provinces would be thrown open to it in addition to the foreign market; but all of the communities on these bodies of water would be benefited, as well as Detroit, which occupies a specially advantageous position. The Lake Superior cities which have so rapidly increased in commercial and industrial importance with the enlargement of the Sault canals would be among those most noticeably affected, since they are shipping points for so many articles of commerce for which the route would afford a new outlet.

THE ORIGIN AND MANUFACTURE OF LAKES.*

All substances and objects in the universe are either chemical units or compounds of chemical units; and we know that they have the property of reflecting or of letting through some portions of the white light, and absorbing some other portions. Thus they appear to themselves of different colors. In the case of chemical elements and compounds, the color varies greatly with varying conditions or states of aggregation. Most elements form colorless compounds, and

If color appears in the latter, it is to be regarded as an exceptional case, and is caused either by the entrance into the compound of some element which has color in itself, or by the chemical consti-



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the route in its present condition is impracticable for navigation by seagoing craft. This fact was demonstrated a few years ago, when a Chicago company endeavored to establish a regular steamship service between that city and Great Britain. The few vessels left Lake Michigan partly loaded, in order to pass through the canals, taking on the balance of their cargoes at Montreal. This extra expense and the delay enforced caused the plan to be abandoned.

This bold attempt to connect the heart of America with the markets of Europe, however, renewed interest in the possibility of such a scheme, and has been a factor in diverting attention to another route, which may be developed into one of the most important of the world's waterways, through which steamships can ply between the principal ports of the upper lakes and the Old World.

In a further study of the map of the continent, a chain of rivers and lakes traversing the province of Ontario stand out conspicuously between the St. Lawrence River and Lake Huron, as apparently forming a series of natural passages from the St. Lawrence River to Lake Huron. This series of waterways has been examined throughout by several prominent engineers, who, after taking measurements of the depths of the several rivers and lakes, the extent of the rapids and waterfalls, studying the formation of the region, and securing other necessary data, have reported that this route can be made entirely practical for a passage for vessels drawing at least 21 feet of water. Maps have been prepared and estimates computed, showing that the maximum cost of completing the waterway will not exceed \$80,000,000. As the result of these reports, negotiations are in progress with English capitalists to advance the funds necessary to defray the cost of construction. This phase of the project has progressed to such a stage that it is possible the work may begin within the next twelve months, as it has the approval and support of many members of the Canadian Parliament.

The eastern terminus of this chain of passages is

Considering the waterway as terminating at Montreal, its total distance from the mouth of the French River is 425 miles. The plans provide for a channel with a width of 100 feet on the bottom, except in the locks, and a minimum depth of about 22 feet. The total length of artificial canal to be constructed is 40 miles, of which four miles comprise locks. Of the remainder of the distance, provision has been made for the excavation of the natural channel to the requisite depth, leaving about 300 miles, which without improvement, has sufficient depth and width for navigation. These dimensions make of the Ottawa-Georgian Bay route a ship waterway of dimensions to float the largest steamer or barge now plying on the Great Lakes. In fact, the locks are planned to allow craft 500 feet in length and 50 feet in width to pass through. A vessel of this size drawing 21 feet of water has a carrying capacity of between 7,500 and 8,500 tons, according to the material to be loaded. As is well known, shipbuilding on the lakes has developed to such an extent that craft of the tonnage mentioned are now in service and included in the fleet of ore and fuel carriers between Lake Superior ports and cities on Lake Erie. It is of interest to note that they equal in dimensions some of the largest transatlantic freight steamships, such as those included in the Johnston, the Elder-Dempster, and other lines running between the North Atlantic ports, London, and Liverpool, while they are larger by from 2,000 to 3,000 tons than most of the so-called "tramp" ships in the carrying trade. Consequently, with the canal completed, a route is opened between the interior of America and the seaports of the world which is available for commerce carriers large enough to be consigned to every part of the globe.

The total distance covered from Chicago to Liverpool by the lakes and the Erie Canal to New York is 4,955 miles, of which 920 is by the lakes, 350 by canal, 145 on the Hudson River, and 3,540 on the sea. The distance, if land transportation is substituted between Buffalo and New York, is 4,913 miles. By way of the proposed canal, the entire distance is but 4,070 miles, for the reason that the length of the inland waterways

tion, that is, the arrangement of the chemical atoms with regard to each other.

The chemical compounds which, in addition to the dyewoods, are of most interest to us here, are coal-tar compounds, belonging to the realm of so-called organic chemistry. Besides carbon, which may be considered the fundamental substance, they usually contain hydrogen, oxygen, and nitrogen, also other elements, and are in the majority of cases colorless. A number of these compounds, however, consisting of the same elements in similar or approximately similar combination in point of percentage, have a very intense color, and compounds of a fixed group of elements, produced under different conditions, causing a different arrangement of the elements, often vary greatly in color, or show none at all. This fact proves with certainty that the presence or absence of color in these compounds, so similar in composition, depends upon their structure.

The real causes of color have so far received little or no investigation, and the constitution of the colored organic compounds was not well known until chemistry succeeded in producing dyestuffs artificially or synthetically. It was noticed in the course of these experiments that certain groups of elements, colorless in themselves, are the cause of the color in organic carbon compounds. These have been named chromophores (color-bearers). If such a group enters an organic compound, no dyestuff results, or even any color. The coloring power of the chromophore must first be released. It was, and still remains, in the language of chemistry, an unsaturated compound; and it must be changed, by the entrance of other elements or groups of elements into the assemblage of atoms, to a compound chemically characterized as an acid or a base. These resulting compounds, which thus have the property of forming salts, according as those of acid character are brought together with basic substances, or the basic ones with acids, are the so-called chromogens (color-producers), and they furnish the real dyestuffs, when the formation of salts

* From the German of Dr. Robt. Ruebenkamp in the Farben Zeitung

is accomplished by the addition of the proper elements or groups of atoms.

This theory, proposed by O. N. Witt, does not, however, cover the whole matter, and there are numerous artificial and natural dyes whose action is not explained by it, and which still await scientific investigation and knowledge.

The idea of a dyestuff is not fulfilled by that of a colored body simply. A dyestuff must be able to impart its color to other substances with which it may be mixed, and this in such manner as to produce not merely a mechanical mixture, but an actual union of the two. To this end it is necessary that both, if possible, but the dyestuff at least, should be in the most finely divided form which we know, that is, in solution. In this way we obtain lakes.

The dyestuffs used for lakes are furnished by the vegetable and mineral kingdoms, in some cases, as for example cochineal and piuri, by the animal kingdom. The principle in the production of lakes from dyestuffs is this, that the dyestuff is precipitated and fixed firmly and insolubly upon white or colorless substances; thus the latter take in the color and form the so-called pigment colors. These colorless foundations of pigments and lakes are called bases or sub-strata, and the chief one for our purposes is alumina. Besides this, heavy spar, "blanc fixe," kaolin, calc-spar, chalk, and starch are used, and in certain cases also such materials as green earth, bolus, red lead, and ochre, in themselves colored.

The difference in the chemical properties of the dyestuffs comes into great prominence in the manifold methods which must be employed for precipitating and fixing them upon the sub-strata. There are some which precipitate themselves directly upon the base, without any assisting agency. Such are the so-called substantive dyes. In contrast stand the adjective dyes, to fix which we need the process of precipitation which takes place through a simple or double decomposition, by means of one or more precipitating agents. These two methods are not always sharply defined, and are occasionally combined. The first process is very simple. The substrata are mixed with water, and the dye is added, with vigorous stirring, until a certain shade of color is reached, or until the substratum will take no more. The mixture is then left to settle; the supernatant water, which should properly be colorless, is drawn off, and the deposit is repeatedly washed, then filtered and dried. The natural substances mentioned above are essentially the ones used as substrata, and the silicic acid they contain seems to be the active agent. The dyes best suited to this method are of basic character, and the silicic acid seems to unite with the color base to form a silicate or silicic salt. Dyes which can be precipitated in this way are such ones as fuchsine, auramine, malachite green, methyl violet, methylene blue, safranine and chrysoidine.

If the fixing power of the substratum is not sufficient, or the process does not go on rapidly enough, certain auxiliary mixtures can be employed. The pigments thus produced are as a rule proof against boiling heat. The methods of precipitating the dyes by the second method are as numerous and complicated as the first process is simple. If basic dyes, such as we have mentioned above, are to be precipitated upon neutral substrata, such as alumina or "blanc fixe," tannin, or tannic acid, is used, with the addition of acetate of soda or antimonious tartrate of potassium. The dyes are thus fixed as tannates or tannic salts. Phosphate of soda is also used for some dyes, as well as silicate of soda and chromate of potassium.

The chief precipitating agent for acid dyes is chloride of barium, the acids forming baryta lakes. The presence of other substrata as admixtures or impurities, the temperature of the liquid, its concentration, and numerous other circumstances, have here, as everywhere in the manufacture of lakes, an important influence upon the depth and brilliancy of the color. This is particularly true of the so-called azo dyes, which may be classed with the acid dyes in regard to the method of precipitation. These give deep and brilliant lakes only at a high temperature, preferably at boiling heat, the reason being that the dyes are soluble only at this temperature, thus capable of forming baryta lakes; at a lower temperature they are not decomposed, but merely enveloped by the substratum and precipitated with it undissolved. Naphthol yellow, azo yellow, orange, Bordeaux, alkaline blue, acid green, and others belong to this class. Occasionally and in special cases, acetate or nitrate of lead, bischloride of tin, alum, tin-salt, or sulphuric acid, are used as precipitating agents.

The important group of the so-called resorcin dyes, to which belong eosine, phloxine, and erythrosine, require acetate or nitrate of lead for precipitation, with which they form lead lakes. By using different substrata or admixtures, it is possible to obtain yellowish or bluish shades from the eosine "geranium" lakes, and special processes give this fineness of all red lakes in a varnish proof quality. Red lead, white lead, "blanc fixe," and more rarely kaolin, are used besides alumina as substrata.

Alizarine, azarine, and galleine make up the group of the so-called mordant dyes; they demand a complicated process of precipitation, which to a certain degree occupies a middle place between the first-named process and precipitation. The dyes are converted into an alkaline solution, that is, into alkaline salts, by means of soda, and then changed through the agency of alum to the alumina lakes of the acid dyes. Through the mutual action of the soda and alum, the substratum—alumina—is formed at the

same time. Turkey-red oil is added, and often calcium salts, which heighten the tone, and determine the shade. The process is begun at the ordinary temperature, and finished at the boiling point. In the manufacture of the artificial madder lakes it is important that neither the materials, the water used, nor even the apparatus, should contain any iron, which would cause a brown discoloration.

It may be briefly mentioned that basic dyes can be fixed by means of certain resorcin, acid and azo dyes; and use is sometimes made of this fact to obtain certain changeable or broken shades.

Whether the precipitation shall be in a dilute or concentrated, cold or warm solution, with or without admixtures; whether it shall be slow or rapid; how many times the deposit must be washed, and at what temperature dried—all these and other particulars must be determined by experiments with each individual color, before its manufacture is undertaken on a large scale.

How the precipitated and purified lakes are dried, and made into disks and other shapes, and what their properties are in regard to the action of light and of varnish, has been already told in earlier articles, and needs no repetition.

We have spoken in general outlines of the different methods of manufacturing lakes, the same for animal, vegetable, or the coal tar dyes. It would, of course, be impossible to give special formulas or methods. These are not only different in the different manufacturers, but are very often kept secret. Neither could a non-expert make use of them.

OBSERVATIONS ON RADIUM.*

By MAX EINHORN, M.D., New York, Professor of Medicine at the New York Post-Graduate Medical School.

In a former paper† I have described radium receptacles for the oesophagus, stomach, and rectum. They serve the purpose of allowing radium to act upon internal organs. Similar instruments can be constructed with minor modifications for other hollow viscera.

In this paper I wish to make some contributions to the method of radium treatment, its physiology (perhaps also its diagnostic value), and to its therapeutic results in carcinoma of the oesophagus.

Method of Radium Treatment—The radium receptacles first constructed were of glass. As this substance is fragile, the question arose whether the capsule could not be made of other material. It is, of course, self-understood that that substance will be most suitable which will best transmit the radium rays. To test this I had constructed capsules of the same size and thickness of glass, hard rubber, bone, celluloid, wood, and aluminium, and subjected them to the following tests: (1) The distance was measured at which a certain quantity of radium inclosed in these capsules would produce a trace of light upon Kahlbaum's barium platinocyanide screen. (2) Photographic plates inclosed in black envelopes were exposed to radium in the different capsules for two hours, the latter resting on a key which had been placed upon the plate. The pictures were then compared with one another. The first test was applied several times. I find among my records the following:

March 19, 1904. 0.25 radium (Curie 20,000) is placed in the various capsules and the distance at which fluorescence still occurs on the screen is measured. The result was as follows:

Glass	5 cm.
Hard rubber	4½ cm.
Celluloid	4½ cm.
Aluminium, not very brilliant even near-by	3¼ cm.

March 20, 1904. The same experiment is repeated with 0.25 radium (Curie 26,000 strength) with the following result:

Glass	4½ cm.
Hard rubber	4½ cm.
Celluloid	4½ cm.
Aluminium	2½ cm.

March 22, 1904. The same experiment was done with 10 milligrammes pure radium bromide (1,000,000 strength) and the following figures found.

Glass	4½ cm.
Hard rubber	3¾ cm.
Celluloid	3¾ cm.
Aluminium	2 cm.
Ivory	2½ cm.

These experiments showed that glass, hard rubber, and celluloid passed the rays of radium better than aluminium and ivory.

A key was photographed with 0.25 radium (Curie 20,000 strength) with two hours' exposure in glass, hard rubber, celluloid, wood (lignum), and aluminium capsules. This photographic experiment also shows that glass, hard rubber, and celluloid transmit the radium rays better than aluminium and wood.

From this it is evident that glass, celluloid, or hard rubber would be most suitable for our purposes. I chose hard rubber, because it is not easily broken, is cheap, and can be conveniently worked, and I have accordingly used these hard rubber capsules almost exclusively in the treatment as well as in our other experiments.

In the radium treatment of internal organs it is

necessary to know how deep, i. e., to what extent the radium rays penetrate. It is probable that different substances vary in their penetrability. To determine this experimentally I had a metal measure case constructed 10 centimeters long and about 1 centimeter broad, with one narrow wall of hard rubber. One of the long sides is divided into centimeters and carries a float, destined to receive the hard rubber capsule containing the radium. The substance to be examined as to its penetrability by radium rays is placed in the box, and the radium capsule is moved until only a faint light appears on the fluorescent screen, which is applied directly to the hard rubber side of the box. This distance can then be read off in centimeters. As an example, I applied the following experiment:

April 23, 1904. 0.25 radium (Curie 20,000 strength) in hard rubber capsule is placed into the float of the measuring box and the distances for the following substances determined:

Air	5¾ cm.
Water	2½ cm.
Milk	2½ cm.
Uranine solution (strongly fluorescent)	2½ cm.

June 16, 1904. The same experiments with 50 milligrammes pure bromide of radium (1,000,000 strength) in hard rubber capsules were repeated. The distances were:

Air	16½ cm.
Water	10½ cm.

(Since the box is only 10 centimeters long, the screen was removed from the box and the distance added.) Among the substances examined air seems to be the best transmitter of radium rays.

Transillumination of Various Organs with Radium.—Mouth.—If 0.25 radium (Curie 20,000 strength) is held in a hard rubber capsule between teeth and cheek and the mouth is closed a strong illumination is produced on the screen. The same capsule held between tongue and teeth produces only a faint light on the screen, i. e., the cheek bones may be transilluminated. Whether this method of transillumination will be of any diagnostic value in diseases of the antrum of Highmore, I am unable to say. It is worth while to determine this more accurately.

Stomach.—The attempt to transilluminate the stomach with the same amount of radium 0.25 (Curie 20,000 strength) was negative. With 0.05 gramme of pure bromide of radium (1,000,000 strength), however, the organ was easily and clearly transilluminated. It is best to use an instrument resembling in its construction the radium receptacle for the oesophagus, which is provided with an opening above the capsule for the inflation of air after introduction. We might call this instrument the "radiodiaphane."

We best proceed as follows: The patient is examined on an empty stomach either before breakfast or seven to eight hours after a meal. The patient must remove all clothing from the thorax and abdomen. The radiodiaphane (containing 0.05 bromide of radium of 1,000,000 strength in its capsule) is slightly moistened with water and introduced into the stomach; the above mentioned Kahlbaum's fluoroscope is applied to the upper left abdominal wall and observed in an absolutely dark room. (The latter is essential; the eyes must also first accustom themselves to the darkness, which usually takes one to three minutes). A figure is then observed resembling the stomach and of the color of the moon. Around this figure a faint halo may be seen to the left above the stomach up to the ensiform process, to the left axillary line and even to the left side of the back (where, however, it is much fainter), i. e., the lungs above the stomach and the diaphragm are transilluminated. To the right the liver does not transmit the rays and the screen remains dark. If the screen is moved further down over the abdomen the illumination usually ceases below the large curvature. Besides we observe a very intense spot of illumination (about the size of a big walnut) which corresponds to the position of the radium capsule. If air is insufflated into the stomach the illumination is more marked. On deep inspiration the illumination becomes weaker, probably on account of the greater distance of the abdominal wall from the radium capsule; on deep expiration, however, the illumination becomes much brighter.

When the radiodiaphane is withdrawn, one observes how the intensely illuminated area (of the size of a walnut) travels upward, to disappear in the region of the ensiform process. When the instrument again descends into the stomach, the light at once reappears.

I have practised radium transillumination in a large number of patients, and am convinced that by means of this method the position of the large curvature can be determined. In patient R. D., for example, it was a finger's width above the navel; in patient N., however, who was suffering from pyloric stenosis, it reached down to the symphysis. A radio-photograph of the stomach of patient R. D. was obtained by placing the instrument on the abdomen of the patient a photographic plate in a black envelope, as used for X-ray purposes. This was thus exposed for an hour to 0.05 bromide of radium (1,000,000 strength) inside the patient's stomach. A safety pin was intentionally interposed between abdomen and plate in order to determine more easily the action of the light.

Colon.—The descending colon, or rather the sigmoid flexure, may also be transilluminated by means of radium. The radiodiaphane for the bowel is of similar construction to that for the stomach. It is only somewhat shorter and made from stiffer rubber, so that no mandrin is necessary for its introduction. Near the capsule the instrument is provided with an open-

* From Medical Record.

† Max Einhorn: "Radium Receptacles for Oesophagus, Stomach and Rectum," Medical Record, p. 399, 1904.

ing to allow the insufflation of air. Before the examination (about half an hour) the bowel must be thoroughly flushed with one to two quarts of water. The radiodiaphane is then introduced as far as is possible without kinking it, and with the patient on the back, the lower abdominal region is inspected with the above mentioned fluorescent screen. Usually there is nothing visible until the air has been insufflated, when translucency occurs on the left side. If the air escapes, the screen becomes darker; if air is again introduced it becomes lighter; deep inspiration lessens, deep expiration increases the translucency. I have tried transillumination of the rectum with radium several times in patients and have always obtained the above results.

Lungs.*—The lungs may be transilluminated from the oesophagus. The radiodiaphane moistened with water is introduced into the upper part of the oesophagus (the distance of the capsule from the teeth should be about 10 or 12 inches) and the naked thorax inspected with the screen. By moving the latter the lungs may be examined both anteriorly and posteriorly. Normally we obtain moonshine color wherever there is lung, only anteriorly on the left side there is a faint shadow corresponding to the heart. We would expect that marked infiltrations of the lung and exudates would cause a change in the normal translucency. This is really the case. As an illustration I will cite the following examples:

May 21, 1904. H. B., suffering from tuberculosis of the lungs, is examined with the radiodiaphane. After a few minutes we find the left half of the thorax above anteriorly and posteriorly well illuminated; the right side, however, showed a more opaque transillumination above anteriorly and posteriorly. If the screen is held toward the middle of the thorax, we see a shadow corresponding to the heart (which, corresponding with the pulse beat, shows apparently a slight enlargement) and light zones on both sides. Below and behind the lungs are also well transilluminated.

June 10, 1904. M. N., a patient of the German Hospital suffering from exudative pleurisy on the right side, is examined with the radiodiaphane by introducing it 12 inches into the oesophagus. The lungs are well transilluminated above anteriorly and posteriorly, whereas, in the lower part of the thorax to the right behind we have a shaded figure, the corresponding part on the left side being brightly illuminated.

The results obtained by transillumination are certainly interesting, primarily as a physiological fact. We see that apparently bones do not offer a stronger resistance to the passage of radium rays than ordinary muscles and skin; they are therefore transilluminated without throwing a shadow. These radium transilluminations may be of diagnostic value. The fact mentioned above, that tuberculosis infiltrations and pleuritic exudates are recognizable by their shadow, seems to point to this. The radium transillumination of the stomach allows an examination of the organ laterally and to the left of the back, both regions that are inaccessible to the ordinary electric gastroduaphane.

We may possibly be able to discover tumors in this manner. The same may be said of the transillumination of the oesophagus. At present I have yet no experience upon this subject.† Therapeutically also these transilluminations of the stomach and lungs may be of value, since they show that sufficient rays pass through these organs to be perceptible to the eye outside of the body. We might therefore expect that we would be able to subject these organs to the therapeutic influence of radium.

Radium Therapy of Esophageal Cancer.—I have treated in all nine cases of carcinoma of the oesophagus internally with radium applications. The radium receptacle for the oesophagus was used with 0.25 Curie's radium (20,000 strength) for one-half to one hour. Otherwise nothing else was done in these cases except regulation of the diet and the occasional use of codeine.

Of the nine cases, six showed an improvement of the stricture. At the same time the patients could take food better. In three cases no improvement could be noticed; in two treatment had not been continued long enough, and in a third treatment had been too irregular to allow us to expect a good result.

Judging from the few cases that have been treated regularly and long enough, it seems to be demonstrated that a partial shrinking of the tumor causing the stricture is the rule. There were never any disagreeable occurrences incident to the treatment. A diminution of the pains could be observed in some cases, but by no means in all.

Although I could not completely cure any one of the cases, the resultant improvement is in itself of sufficient importance; the more so as we are dealing here with a condition against which we are entirely powerless (even surgically). If it is, therefore, possible to render the stricture more pernicious by means of radium treatment and thus keep the patients alive for a somewhat longer time, it means a step forward.‡ Perhaps it will be possible to obtain even a cure in some cases by beginning treatment before the cancer has as yet progressed far. Further research on this subject is certainly desirable.

* The transillumination of the stomach and lungs by means of radium was demonstrated by me on a patient at a meeting of German physicians of New York, May 27, 1904.

† Since writing this paper I have been able to diagnose once an intrathoracic and once a gastric tumor by the lack of translucency with the radiodiaphane.

‡ Since this paper was written, A. Exner (Wiener klinische Wochenschrift, 1904, No. 4) has reported three cases of esophageal cancer treated by the same method, in which there was a dilatation of the stricture as a result of the radium applications.

ENGINEERING NOTES.

A log raft containing 10,000,000 feet of lumber, 725 feet long, 35 feet in breadth, with a depth of 23 feet, recently reached San Francisco. If cut up into boards it is said that it would be ample to load a score of ordinary schooners engaged in the coast lumber trade.

The new harbor at Osaka (Japan) has now been opened for traffic. Although Osaka is the headquarters of the rice and tea trade, its harbor formerly was only sufficient to admit small craft. Large vessels were compelled to discharge at Kobe, the neighboring port.

An amended definition of the term Portland cement has been adopted by the Association of German Portland cement manufacturers. It is, in this, defined to be a hydraulic cementing material of specific gravity not less than 3.1 in the calcined state, and containing not less than 1.7 parts by weight of lime to each one part of silica + alumina + iron oxide, the material being prepared by mixing the ingredients intimately, calcining them to not less than clinkering temperature, and then reducing the whole to the fineness of flour.

One of our recent British engineer visitors, Mr. John W. Spencer, is reported in Engineering (London) as having said in an address that "bigness was the keynote of American manufacturing policy. So far as he could judge, there was not much very far ahead of what could be seen in this country, if one put aside the enormous output. This, however, involved enterprise, and the huge machinery was designed for this great end of gigantic production. In one case, of which he had been told, the director of the works called the managers of departments together and asked what they were turning out. The reply was so much, to which the director replied, 'Then double the plant.' It was the same everywhere, no matter what the line of business was; huge works and tremendous output were the order of the day. . . . The Allis-Chalmers Company had just laid down a plant which would give employment to four or five thousand men; but this was only one unit out of thirteen. Another general feature was the energy with which every one went about his work, whether it was manager or workman. He had tried to account for this. He found on inquiry that many of the chief men in works, either managers or foremen, had come from this country, and therefore one had to look for some other cause than birth or racial characteristics. He found that those who were tempted over were chiefly influenced by the opportunity of reaching to a better position than that for which there was a prospect in this country. So far as the workmen were concerned, the unions were largely responsible for this; for over in America men who had the energy to raise themselves to superior positions also had the opportunity. In conclusion, Mr. Spencer would advise every engineer who could possibly get there to visit America; to see not only the bigness of the works, but the large amount of skill displayed by Americans in carrying out their enormous undertakings."

The behavior of superheated steam in piston engines was made the subject of a study by F. Richter in Zeitschr. Vereines Deutsch. Ing. The purpose of the tests was to determine the influence of the degree of superheat on the expansion curve and on the mean temperature of the sides of the cylinder. The engine used was a triple-expansion engine of 150 horse-power with surface condensation. All the principal dimensions are given in a drawing, and the calculated as well as the observed values of the cylinder clearances are given in a special table. Great care was bestowed on the checking of the indicator, and the results of these preliminary tests lead to interesting conclusions as to the comparative values of indicators with internal and external springs. The main tests were restricted to the high-pressure cylinder and were arranged so that at constant cut-off and constant pressure the temperature was increased, step by step, up to 300 deg. C., while in a second set of tests the temperature and pressure were kept constant and the cut-off altered. The diagrams which the writer obtained were corrected, and especial importance was laid on the expansion curve, as it was the principal aim of these tests to find the law of the expansion curve under different conditions. The general equation for the expansion curve is $p'V_m = \text{const.}$, where p' = absolute pressure, V = volume of steam, and m = a coefficient. The coefficient m has different values according to the influences prevailing; if heat passes into the steam, m will be comparatively small, and vice versa. To show very clearly the value of m at any point of the expansion curve, the logarithms of p and V have been taken, in accordance with the equation $\log p' + m(\log V) = \text{const.}$ For constant values of m , this new expansion curve will be a straight line, and for any other curve the angle of the tangent to a given point of the curve will readily show the corresponding value of m . To further facilitate the comparison of the different sets of curves, a tri-vector diagram has been used, the value of logarithm (p) appearing as the ordinate on a plane; each line of the plane representing a complete set of curves. These diagrams form a ready means of studying the principal phenomena occurring during the expansion of the steam in piston engines, such as the influence of the sides of the cylinder in taking heat from the steam during the first part of the expansion and restoring heat to the steam during the following stage. The comparative values of this effect for high and low superheat and for different values of the cut-off, may be readily obtained.

ELECTRICAL NOTES.

The United States Secretary of Agriculture has decided to install a wireless telegraph system of fire alarms in all government forest reserves throughout the country.

According to the Electrical World of New York Gen. Greely, chief signal officer, U. S. A., received on August 9 the first wireless telegraphic message sent direct from Nome, Alaska. It marks the inauguration of the government wireless line from Nome to St. Michaels, 107 miles.

The manufacture of calcium carbide in the electric furnace needs a large amount of power. A year or so ago it was usual to reckon that a horse-power year was necessary to produce a ton of carbide. Now, according to Mr. Bertram Blount, modern works succeed in turning out as much as 1½ tons for the same expenditure of power.

Reuter's correspondent at Tsing-Tau reported last week an interview with Admiral Matussevitch, who was wounded on board the "Cesarevitch" during the last naval engagement off Port Arthur, and is now in hospital at Tsing-Tau. Admiral Matussevitch spoke in the highest terms of the usefulness of wireless telegraphy. In the fight on August 10 the apparatus on board the "Cesarevitch" continued working until it was shot away. It had worked more surely and quickly than flags, and he believed that in the near future every boat of all navies, even gunboats, would be fitted with wireless telegraph apparatus.

V. Calzavara presented a memoir at the Congress of the Deutscher Verein von Gas und Wasserfachmännern, Zürich, June, 1903, in which he states that the application of centrifugal force for the separation of liquid substances has given rise to a number of useful machines, but until recently it was not thought possible to separate gaseous mixtures by its means. E. N. Mazza has succeeded in solving the problem. His separator is a very simple machine, and consists of a drum revolving with high velocity, into which the gaseous mixture is sucked and the components divide into various strata according to their densities, and escape by different outlets. Even when the difference of density between the components is not great a certain amount of separation can be brought about. Thus air can be divided so that one portion is so enriched with oxygen as to be useful in feeding under boilers and with greater fuel economy. At several works air so treated has increased the thermal yield from fuel from 16 to 23 per cent. A number of authorities have confirmed the novelty and usefulness of the invention. The present article deals more especially with the use of the separator in the gas industry. With a drum of 40 centimeters radius, and revolving at 1,000 revolutions per minute, the best results are obtained when applied to the constituents of coal gas. A number of important uses of the method are described, of great importance in gas works. Blast-furnace gas could be enriched by the removal of about 17 per cent of the inert and noxious gases, and hence would be rendered more suitable for use in gas engine. The method seems likely to have a considerable industrial success in a great variety of applications.

The common devices for the protection of transmission lines from lightning and other static stresses are being constantly modified, so that it is apparent that improvement is needed with this apparatus. To develop such devices the transmission lines should be carefully examined, and also apparatus which may have been damaged by h. t. discharges. Overhead ground wires have been used in several plants. These should be large enough not to break, and be of material which will resist corrosion. A suitable wire will cost almost as much as an additional transmission wire. In a certain 40,000-volt plant, feeding 90 miles of line, the greater part of which was protected by galvanized iron wire at the tops of the poles, and grounded at every fifth pole, no poles have been shattered by lightning since the installation of this wire. Previous to this poles were frequently shattered. Had lightning arresters been used with no overhead wires, there would have been no damage to apparatus, but the poles would have been shattered. Lightning arresters are not commonly used on transmission lines, but it is not known whether poles can be protected in any other way than by overhead ground wires. The author is of opinion that the line can be protected by suitable apparatus in the stations without the use of ground wires. In another case of a plant operating at 25,000 volts, since installing lightning arresters to break down at 50 per cent above working pressure, no damage to apparatus has occurred at the stations. A new type of arrester has recently been suggested, called the multiplex connection, in which a shorter path is provided from line to line, requiring practically the same breakdown pressure as from line to ground. Regarding reactive coils in connection with lightning arresters there is much difference of opinion. Some tests showed that the best lightning arresters could not protect the apparatus until such coils were used. Although much has been written on lightning arresters there is little valuable information on the relative pressures suitable for the spark-gap. It is difficult to state how near the generator pressure the spark-gap can be adjusted without danger of flashing over. Experience alone can determine this point. Present practice would indicate that apparatus to be safe should stand an insulation test of 100 per cent greater than rated pressure for one minute. Experiments have shown that very high pressures exist momentarily between the outside turns of a transmission coil when it is switched into or out of circuit.

SCIENCE NOTES.

Evidence of flow under the action of mechanical forces has been observed by Beilby in the case of pure metallic antimony (observations on speculum metal have already been described), but the smooth, flowed surface can be removed by lightly etching with potassium cyanide, revealing the ridges and furrows produced by the emery but disguised by the subsequent polishing with wash-leather. The forces required to produce flow in a freshly-cleaved surface of calcite are extraordinarily small; a single stroke with the finger covered with clean, soft wash-leather showed unmistakably on the etched surface, but this could be removed by further etching with 0.2 per cent acid for 30 to 60 sec.

The rise of a spinning top is described by E. G. Gallop in Cambridge Phil. Soc. Trans. The air friction is neglected, and the assumptions made with regard to the friction between the top and the ground are that it may be represented by a single force at the point of contact, and that when slipping takes place the direction of the force of friction is opposite to the direction of sliding, or at any rate acts so that energy is dissipated. The treatment is mathematical, but arithmetical examples are given. *Inter alia* it is proved that the permanent state of rotation with axis vertical cannot be attained without dissipation of energy, and conversely that if sufficient energy be lost the axis must become permanently vertical. Various types of top are considered.

"The metric controversy," says Prof. W. Le Conte Stevens in a recent article in Science, "may be summed up in a few words. Certain people wish to give to our weights and measures the same simplicity that characterizes our system of coinage, and in the remote future to attain international unity of coinage, weights, and measures. Certain other people would lose money and otherwise suffer much inconvenience by the change. No good can result from calling the former doctrinaire or denouncing the latter as selfish. We have to consider the practical question, Is the game worth the candle? If so, how can the transition be made less burdensome? If not, how can the existing system be improved with least inconvenience? Each of these questions may receive a different answer, and none of them will be fully answered during the twentieth century."

Radiactivity of Natural Gas.—Prof. T. C. McLennan, of the University of Ontario, gives in Nature particulars of some experiments on the radioactivity of the natural gas from different wells in Western Ontario, including those in the Welland district, in the neighborhood of Niagara Falls, as well as those near the city of Brantford. In every case the gas was found to be charged with a radioactivity varying in amount; and in all the gases tested the strength diminished to one-half its original intensity in about three days. The intensity of the induced radioactivity which it produced died down to one-half value in about 40 minutes. The depths of the wells examined varied, but the amount of active emanation present was found to be practically the same in all the wells at the same depth. In the Welland district the gas coming from the stratum known as the Niagara formation, at a depth of about 500 feet, had the highest initial conductivity, which, on an arbitrary scale, is represented by about 2,000. The gas from wells in the Clinton limestone, 750 feet deep, had an initial conductivity of about 300 on the same scale, while from wells in the Medina formation, at a depth of about 900 feet, the initial conductivity was about 1,200. One well, having its source in the Trenton limestone, possessed an initial conductivity of about 200 at a depth of about 3,000 feet. The experiments showed that the highest conductivity obtained was that of a gas from a well near the city of Brantford, in which case it was about 9,000.

In Jour. and Proc. of Royal Society N. S. Wales, A. Liversidge gives descriptions and analyses of meteoric or atmospheric dusts, notably of specimens which fell at Moruya on December 15, 1880, and of dust collected from the beams underneath the roof, and in a cistern of the University and Observatory buildings at Sydney. The Moruya dust, like several specimens, seemed to be essentially of terrestrial origin, and to have come from dried-up fresh-water pools; but the 0.009 gramme of magnetic matter, and possibly also some earthy matter in the 27.5 grammes of dust, were probably meteoric. The 4.94 grammes of roof dust contained 1.5 per cent of magnetic matter, metal or oxide of iron with both cobalt and nickel. The tank dust had apparently been accumulating for thirty years. The traces of gold and platinum found may also be meteoric. Discussing the dust finds of Tissandier (Tower of Notre Dame, Paris) Nordenskjöld (Arctic snows), A. Schroeter (African deserts), and others, the author concludes that the presence of cobalt and nickel in iron is not a proof of its meteoric character. Both these metals occur in commercial iron, have been found in the soot from coal by H. Hartley and H. Ramage, and G. C. Hoffmann has discovered them also in the spherulitic iron of St. Joseph Island, Lake Huron. Gentle falls of meteoric dust are, no doubt, frequent, but they do not cause our ordinary dust storms, haze, ash and mud rains, etc. A large portion of the paper is taken up by references to dust storms and similar phenomena observed in Australia and all over the world. A very remarkable dry fog traveled rapidly over an immense area of the Murrurundi district on October 12, 1876; no dust was collected in this case.

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